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# The metaphysics science needs: Deleuze's naturalism

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**Abstract**

This article is aimed at those interested in the philosophy of Gilles Deleuze and the sciences—and this includes philosophers of science working out of the analytic tradition. Deleuze's writings are riddled with references to science and mathematics. And yet, the relation between these references and his philosophical thought is not well understood. In this essay, I investigate the nature of this relation—and I do so by asking whether it is naturalistic. Importantly, I draw on insights from contemporary philosophy of science to contribute to a proper understanding of this issue. I show that and how commentators are hamstrung by their lack of engagement with the philosophy of science; I present an interpretation of Deleuze's philosophical project as attempting to articulate an immanent and primitive form of objective modality; I draw together parts of Deleuze's corpus that are relevant to his treatment of the sciences but are nonetheless rarely studied in conjunction (including his and Guattari's distinction between 'major' and 'minor' science and his under-scrutinized statement of interest in 'the metaphysics science needs'); and I propose a naturalistic interpretation of his engagements with science.

## 1 | INTRODUCTION

The work of Gilles Deleuze is riddled with references to mathematics and the sciences. And yet, the relationship between these references and his philosophical thought is not well understood. This is not to say that Deleuze's

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engagements with science and mathematics have gone unacknowledged. On the contrary, a wing of the interpretative scholarship is more or less dedicated to emphasizing these engagements, giving rise to what Gaffney labels the ‘scienticity’ polemic in Deleuze studies (2010, p. 7). But such scholarship typically focuses on elucidating Deleuze’s claims in light of these engagements, rather than examining the relation between the two. In other words, such scholarship almost never explicitly thematizes Deleuze’s ‘naturalism’—the rubric under which the relation between philosophy and science (at least in the analytic tradition) is usually studied. As Patton remarks (in one of the few essays dedicated to this topic): ‘The question whether or not Deleuze can be considered a naturalistic philosopher and if so in what sense of the term “naturalist” is not one that has been widely discussed in the secondary literature’ (2016, p. 348).

This is true even despite claims to the contrary. Consider, for example, the following from Protevi:

Since the early 1990s, a number of works (among others, Massumi, 1992; DeLanda, 2002; Bonta & Protevi, 2004; de Beistegui, 2004; Bell, 2006) have claimed that Deleuze offers a naturalist ontology that maps well onto wide-ranging current research projects that use nonlinear dynamic systems modeling.

(2013, p. 1)

Protevi’s claim notwithstanding, not one of the cited authors dwells on the question of naturalism. Not one of the works mentioned, for instance, includes an index entry for the term. Neither Massumi (1992) nor DeLanda (2002) nor Bell (2006) use the word at all. de Beistegui uses the word in conjunction with Deleuze’s name only once, toward the end of his book, at which point he claims to have ‘shown that ontology can and must be as open to naturalism as to phenomenological intuitionism’ (2004, p. 338). And Bonta and Protevi allude to naturalism only twice, each time describing it in terms of the anti-humanist desire to ‘analyze social systems with the same basic concepts’ used to ‘analyze organic and inorganic systems’ (2004, pp. 4, 92). Protevi himself does briefly acknowledge the slipperiness of the term, though he ultimately just reiterates his and Bonta’s position that ‘Deleuze is a naturalist qua anti-humanist’ (2013, p. 1, n. 2). Suffice to say, and to reiterate Patton’s claim, the question concerning Deleuze’s naturalism, and of how precisely we ought to understand ‘naturalism’ in this context, is severely underexamined—even among those who place Deleuze’s scientific engagements at the center of their interpretative projects.<sup>1</sup>

Such lack of interest in these questions is surprising, especially given the oft-cited aim of fostering discourse with philosophers working in the analytic tradition. DeLanda, for instance, states that the mission of his *Intensive Science and Virtual Philosophy* is to ‘present [...] Deleuze to an audience of analytical philosophers of science’ (2002, p. 1).<sup>2</sup> And yet he ignores what is perhaps that audience’s most elementary piece of descriptive and conceptual vocabulary, instead couching his (and Deleuze’s) work in the language of ‘materialism’, itself now recognized as patently non-naturalistic.<sup>3</sup> Such oversight, I argue, is illustrative of a broader failure to connect Deleuze’s thought to the ideas and problems that exercise contemporary philosophers of science, resulting in a figure who, despite best intentions, remains opaque to this repeatedly targeted demographic.

Nonetheless, an emerging interest in Deleuze is observable within the recent philosophy of science literature. Calamari (2021) asks whether Deleuze provides the appropriate metaphysics for loop quantum gravity; Dewar (2023) speculates as to whether Deleuze affords conceptual resources that might furnish a category-theoretical account of the representation of scientific theories; and van Fraassen and Peschard (2008) cite Deleuze in their essay on identity over time.

This article therefore takes up the following twofold challenge: (i) to make better and more precise sense of the relationship between the sciences and Deleuze’s philosophical claims, and indeed to contribute to a proper understanding of this issue; and (ii) to do so in a way that better advertises both the novelty and relevance of such claims to philosophers of science, thereby fanning the flames of their aforementioned emerging interest. Both folds, I argue, can be tackled by promoting a more concerted effort to put Deleuze more directly into contact with the ideas and nomenclature of contemporary philosophy of science, and in particular by investigating, with reference to developments in the analytic tradition, the question of his naturalism.

I should emphasize that what interests me here is ‘naturalism’ in the analytic (and perhaps more mainstream or popular) sense of the word. That is, ‘naturalism’ as describing some relation between philosophy and the sciences. I am *not*, then, going to focus on Deleuze’s own occasional use of the term in reference to the part-speculative, part-practical naturalisms of Lucretius, Spinoza and Nietzsche.<sup>4</sup> The literature on this topic is already much more abundant.<sup>5</sup> And while there are undoubtedly interesting continuities and discontinuities to be discovered between our science-related sense and Deleuze’s own, our understanding of this relationship requires that we first get to grips with that between the sciences and Deleuze’s thought.

I should also establish some preliminary understanding of what we mean by ‘naturalism’, even if this understanding itself comes under critical scrutiny during the course of this essay. Here we can employ the well-worn distinction between naturalism of an ‘ontological’ and a ‘methodological’ sort. Roughly speaking, ontological naturalism concerns our metaphysical commitments: there is what the sciences say there is and the metaphysician is constrained by this ontology in some important way. They cannot, for instance, accept the existence of God, the soul, ghosts, or any other supernatural or otherwise ‘spooky’ entities. Methodological naturalism, on the other hand, concerns *how we arrive* at these commitments: science is our best (and perhaps only) way of knowing the world and so it ought to serve as the primary source of information for metaphysical deliberation.

Though I propose an interpretation of Deleuze as naturalistic in both the ontological and the methodological sense, note that I raise the question of naturalism in order to elucidate the relation between the sciences and his philosophical claims. Deleuze’s engagements with art, literature, cinema, the history of philosophy, and other non-science obviously do bear on the ultimate determination of his naturalist status, but here I restrict my attention almost entirely to his engagements with science (and whether they qualify as naturalistic) rather than his engagements with non-science (and whether they qualify as non-naturalistic).<sup>6</sup>

The structure of the article is as follows. First, I provide a precis of Deleuze’s philosophical project. Second, I examine what few attempts to determine Deleuze’s naturalist status do exist in the relevant literature. Drawing on resources from the analytic tradition, I argue that such attempts fail to reflect the commitments of the sciences and otherwise suffer from lack of engagement with contemporary philosophy of science. This section is the longest in the essay, partly because I want to familiarize the reader with the relevant philosophy of science and partly because doing so allows me to advance my claim that Deleuze’s philosophy is in fact consistent with ontological naturalism. The rest of the paper is concerned with methodological naturalism. In the third section, I examine how the question of naturalism emerges in Deleuze’s philosophical writings. I examine his oft-cited (though rarely scrutinized) statement of interest in ‘the metaphysics science needs’ and I draw upon some helpful descriptive machinery from May (2005) concerning his ‘two levels’ of engagement with the sciences. In the fourth section, I reconstruct and critique a common exegetical strategy for resolving the question of Deleuze’s naturalism in favor of a non-naturalistic interpretation. In the fifth section, I introduce Deleuze and Guattari’s distinction (neglected in this context) between ‘major’ and ‘minor’ science. I argue that we can best make sense of this distinction, along with Deleuze’s various engagements with the sciences, if we read him as adopting a form of ‘minor’ methodological naturalism.

## 2 | DELEUZE’S PHILOSOPHICAL PROJECT

Deleuze is a self-described ‘pure metaphysician’ (1999/2007, p. 42), one who advocates a ‘systematic’ approach to ‘classical’ philosophical problems (1993/2010, p. vii). One might therefore be excused for expecting a (relatively) straightforward reading experience. And yet, anyone who picks up a copy of *Difference and Repetition*, or any of his other books or essays for the first time, will most likely find his rhetorical style baffling and perhaps more than a little frustrating. His prose often lacks any clear or discernible organization and is regularly packed with allusions to an immense array of philosophical, scientific, and artistic figures and ideas—some canonical, others marginal, and many not properly cited or referenced. Rather than betraying deliberate obscurantism or an inability to organize his ideas

effectively, however, much of this rhetorical weirdness can be attributed to Deleuze's radical approach to his classical concerns: namely, his philosophy of *difference*.

Deleuze claims that difference is fundamental. That is, he reverses our traditional and commonsensical conceptions of the relations of logical and ontological priority that obtain between difference and identity. Where one might typically assert that difference can obtain only between already given identities or individuals and thus ought to be understood derivatively, as the negation of identity or as *non-identity*, Deleuze argues that it is in fact identities or individuals that are derivative, emerging from a 'pre-individual field [...] of differential relations' (1968/1994, p. 246) or from a logically and ontologically anterior form of 'difference in itself' (1968/1994, p. xix). 'All identities are only simulated, produced as an optical "effect" by the more profound game of difference and repetition' (1968/1994, p. xix); 'Every object, every thing, must see its own identity swallowed up in difference, each being no more than a difference between differences' (1968/1994, p. 56); 'difference is behind everything, but behind difference there is nothing' (1968/1994, p. 57).

This reversal has profound consequences not only for our understanding of the world but for understanding *as such* on Deleuze's view. If the world proves to be fundamentally differential, then our account of that world, its descriptive and explanatory structure, must follow suit. A properly coherent philosophy of difference (so the argument goes) can thus only be communicated by means of difference or differentiation. As Bryant observes (referring specifically to *Difference and Repetition*): 'to be consistent with what it argues [...] it must differ from itself and it must differ in its reader' (2020, p. 10). Deleuze therefore writes in such a way that forces such difference upon his reader. One always finds oneself 'in the middle' with Deleuze, always already inserted into lines of thought which are themselves, with their allusive flurries and interwoven structures, always already branching out in multiple directions.<sup>7</sup> This forces one to read selectively and to leverage one's understanding against what is more familiar and accessible both within and without the text at hand. We therefore take up an active relation to Deleuze's thought; we must (quite literally) *make sense* of his philosophy of difference. And, precisely because one's selection and leveraging processes always individuate one's understanding in a peculiar way, this production of sense is also always a production of difference. Deleuze may regard himself as a 'classical' philosopher, then, and he may 'believe in philosophy as a system', but owing to his unorthodox response to his classical concerns that system 'must [...] be in perpetual heterogeneity, it must be in *heterogenesis*' (1993/2010, p. vii). Hence his bizarre rhetorical style.<sup>8</sup>

Deleuze's project has two components. On the one hand, he seeks to show that the tendency to subordinate difference to identity (what he calls 'representation' or the 'image of thought')<sup>9</sup> is self-undermining and leads to all kinds of intractable problems and contradictions. On the other hand, and as already indicated, he attempts to articulate his own metaphysics of difference. It is this second, positive component that interests us here.

In keeping with his requirement for systematic heterogeneity, Deleuze cashes out his metaphysical vision in a variety of technical vocabularies. One such vocabulary, and indeed one that persists throughout most of his career, is that of the 'actual' and the 'virtual'. The actual is the empirical domain of individuals or objects ordinarily understood. Here identity reigns as difference is conceived only as the difference between things: 'difference remains subordinated to identity, reduced to the negative, incarcerated within similitude and analogy' (1968/1994, p. 50). And it is by modeling our understanding of what the world is really like on the actual that we become mired in the world of representation on Deleuze's account:

Forms of the negative do indeed appear in actual terms and real relations, but only in so far as these are cut off from the virtuality which they actualise, and from the movement of their actualisation. [...] the negative is always derived and represented, never original or present: the process of difference and of differentiation is primary in relation to that of the negative and opposition.

(1968/1994, p. 207)

This 'virtuality' to which Deleuze refers is the domain of pure difference. There are no individuals or objects in this domain; only difference and the above-mentioned 'difference between differences' (1968/1994, p. 56) through

which such things emerge. Deleuze (unsurprisingly) refers to the purely differential quality of the virtual as ‘differentiation’, whereas he refers to that process through which actual identities and the differences between them are produced (alluded to in the just-cited passage but the details of which we cannot inspect here) as ‘actualisation’ or ‘differentiation’: ‘We call the determination of the virtual [...] differentiation; we call the actualisation of that virtuality into [actual] species and distinguished parts differentiation’ (1968/1994, p. 207).

Note that the actual for Deleuze has no modal significance, as it does for the contemporary analytic metaphysician. ‘Actuality’ simply describes the quality of being a discrete individual, object, or state of affairs with some intrinsic identity profile. Thus, for Deleuze, a possible man in a doorway is just as actual (in his sense) as an actual man in a doorway (in the analytic metaphysician’s sense). And it is for precisely this reason that he rejects the notion of the possible as an artifact of representation. That is, the possible assumes ‘the form of identity in the concept’, or depends upon ‘the identical as a prior condition’ (1968/1994, pp. 211–212), in so far as it models itself on the actual and thus inherits its individuated and identity-prioritizing structure. ‘Such is the defect of the possible’, Deleuze writes, ‘a defect which serves to condemn it as produced after the fact, as retroactively fabricated in the image of what resembles it’ (1968/1994, p. 212). (We consider Deleuze’s views on modality in more detail in the next section.)

Another idiom through which Deleuze articulates his metaphysics of difference is that of ‘intensity’: ‘Everything which happens and everything which appears is correlated with orders of differences: differences of level, temperature, pressure, tension, potential, *difference of intensity*’ (1968/1994, p. 222).<sup>10</sup> As Mader points out, Deleuze fastens upon this notion because intensities enjoy a ‘necessarily ineliminable structuring difference’ (2014, p. 225). Consider temperature, to borrow one of Deleuze’s preferred examples. Note that equilibrium or constant states of temperature typically occur only by means of ‘canceling-out’ processes. The heat of a sauna is reached and sustained only by the difference in temperature between its hot coals (or whatever heating mechanism it happens to use) and the world outside. Remove the coals and the heat dissipates into the surrounding environment, itself an ocean of temperature and pressure differentials. Thus, on Deleuze’s account, ‘each temperature is already a difference’ (1968/1994, p. 237). Also, temperatures are not composed mereologically out of other temperatures. We might measure and typically think about them in terms of discrete and homogenous units or degrees, but such treatment obscures their intensive and *qualitative* (as opposed to *quantitative*) nature. Again, temperatures are produced by the canceling- or averaging-out of differences; degrees of temperature do not add up or divide in the way that the volumes or lengths measured by thermometers do. In Deleuze’s words, they lack the ‘equivalence of the parts determined by the unit’, as well as the ‘consubstantiality of the parts with the whole’, and so ‘imply series of heterogeneous terms’ (1968/1994, p. 237). Thus, he sees in temperature and other intensive phenomena a model for his philosophy of difference: ‘Every intensity is differential, by itself a difference’ (1968/1994, p. 222); ‘Every phenomenon refers to an inequality by which it is conditioned. Every diversity and every change refers to a difference which is its sufficient reason’ (1968/1994, p. 222).<sup>11</sup>

Intensities are for Deleuze contrasted with *extensities*, which are essentially quantitative in nature and which characterize discrete entities and their individual parts (their volumes, areas, lengths, and so on). Importantly, extensity is derived from intensity on Deleuze’s view: ‘the fiction of a homogenous quantity vanishes with intensity’ (1968/1994, p. 237); ‘intensity is an implicated, enveloped or “embryonised” quantity’ (1968/1994, p. 237).

In our fourth section, we examine the idea of intensity as ‘embryonised’ quantity or extensity more closely in the context of early twentieth-century embryology. My aim in this section is not to engage in lengthy exegesis, nor is it to defend Deleuze’s philosophical claims. Rather, my aim here is merely to establish some familiarity with those claims so that we can investigate how Deleuze’s engagements with the sciences figure in their articulation—and in particular whether they do so naturalistically.

### 3 | NATURALISM AND DELEUZE

The question of Deleuze’s naturalism, we saw in the introduction to this essay, is rarely made explicit in the relevant literature. That said, attempts to articulate and address this question do exist—the most prominent, sophisticated,

and sustained of which belong to Patton (2016) and Ansell Pearson and Protevi (2016). Such attempts fail, however, because they either adopt a conception of naturalism that is not supported by the sciences, and so they lack an appropriate standard against which to judge Deleuze's naturalist credentials, or they fail to engage sufficiently with the philosophy of science more broadly. Examining how this is so allows us to establish more suitable demarcation criteria for naturalistic philosophy and, I argue, to recognize that Deleuze's thought is in fact consistent with a more scientifically credible form of ontological naturalism.

### 3.1 | Patton on ontological naturalism

Drawing on the likes of Armstrong and Papineau, Patton defines ontological naturalism in terms of the well-known notion of 'causal closure', 'whereby physical states or events are caused only by physical states or events' (2016, p. 351). Such closure is also described in terms of the 'completeness' of the physical realm. That is, once a description of a particular physical effect contains all its physical causes, then that description is *complete*: 'we never need to look beyond the realm of the physical in order to identify a set of antecedents which fixes the chances of any subsequent physical occurrence' (Papineau, 1993, p. 16). As Patton observes, naturalism in this sense admits of strong and weak versions. The former insists, à la Armstrong, that 'the world contains nothing but the entities recognized by physics' (Armstrong, 1980, p. 156; cited in Patton, 2016, p. 351); the latter allows, à la Papineau, for 'the existence of non-physical states or events' (Patton, 2016, p. 351), though only on condition that they 'are identical with or realized by physical states' (Papineau, 1993, p. 103). Thus, there might exist entities that are non-physical (in the sense of not being studied directly by physics) such as mental states or biological organisms, but whatever does exist must be entirely explicable only in terms of *physical* cause and effect. As soon as one accepts the causal influence of the non-physical over the physical, then one no longer qualifies as naturalist in the ontological sense.

Patton therefore concludes that Deleuze's ontology cannot possibly be naturalistic because, though much of his project is defined by a relentless critique of metaphysical transcendence, Deleuze nonetheless 'endorsed the existence of some decidedly "spooky" entities such as pure events, abstract machines and other kinds of virtual reality' (2016, p. 352). And such entities, Patton rightly notes, do have some bearing on how things go in physical nature. Much of Deleuze's project consists in detailing the 'virtual origins of particular domains of thought and empirical reality' and articulating the 'complex processes by means of which virtual structures are actualized in spatio-temporal form' (2016, p. 352). Deleuze's philosophy, Patton claims, is therefore 'inconsistent with the modern scientific image of the world as a single, closed causally interconnected system' (2016, p. 352).

But Patton is mistaken, as are those whose work he draws upon to articulate his view, about the basic character of 'the modern scientific image of the world' and thus about what qualifies as conforming to that image. For there exists a rich (though perhaps minor) literature that casts doubt on the appropriateness of the concept of causation in physics. This literature goes back to Russell (1913) and winds its way more recently through Redhead (1990), Glymour (1999) and Norton (2007).<sup>12</sup> Though not all of Russell's original claims survive scrutiny,<sup>13</sup> the claim that there are no causes in physics remains credible and is accepted broadly to this day: 'it is widely believed among philosophers who have looked carefully that there are no causes in fundamental physics' (Ladyman, 2008, p. 751).

Redhead, for example, maintains that physics describes not causes but relations of 'functional dependence' or 'how one physical magnitude is related in a regular [...] fashion with another physical magnitude' (1990, p. 146). Thus, the pressure exhibited by an ideal gas at constant temperature upon the walls of its container is not *caused* by that container's volume. Rather, volume and pressure here merely 'coexist in a manner regulated by Boyle's law' (1990, p. 146). Similarly, the vertical distance  $s$  traveled by a plummeting cannonball at time  $t$  can be described by Galileo's law,  $s = \frac{1}{2}gt^2$ . Such distance is obviously not caused by time elapsed nor can the cannonball's position at some time be caused merely by its position at an earlier time. The best candidate for a cause here is the accelerative force of gravity  $g$ . And yet,  $g$  is itself merely an expression of the functional relationship between  $s$  and  $t$ , or 'the acceleration is just *defined* by the kinematic relationship expressed in Galileo's law' (1990, p. 146), and so is nothing

over and above that relationship. For Redhead, ‘the idea that forces “cause” bodies to move is a very anthropomorphic notion’ (1990, p. 146), stemming perhaps ‘from the idea of our interfering in the natural course of events, pushing and pulling objects to make them move and so on’ (1990, p. 147). But gravity and other forces do not intervene in the natural order of things as we might in a laboratory setting. Rather, they are part of that natural order. In each instance, then, we encounter not causes but reciprocal determining relationships expressible by some equation or another: ‘In modern physics there are just regularities’ and such regularities ‘are all “natural” and hence leave no room for causation’ (1990, p. 147).

That eliminativism about causes in physics is taken seriously raises problems for the claim that what counts as naturalistic ontology ought to be understood in causal terms. This is a complaint leveled by Ladyman et al. directly against Papineau and others who endorse a principle of causal closure: ‘one might deny that there are causes in physics [...] and so deny the causal closure of the physical’ (2007, p. 44, n. 43). If physics recommends, or at the very least supports, a description of the world that is non-fundamentally causal, then a causal-closure account of ontological naturalism itself proves to be non-naturalistic. Patton therefore lacks a legitimate yardstick against which to measure Deleuze's naturalism.

### 3.2 | Deleuze and objective modality

Before we turn to Ansell Pearson and Protevi, I want to discuss Patton's claim that Deleuze ‘endorsed the existence of some decidedly “spooky” entities’ (2016, p. 352). Here I think Patton conflates ‘spookiness’ with a commitment to objective modality. That is, with the belief that there are real features of the world (such as laws, essences, or dispositions) that determine not only what *is* but what *might* be or *could* otherwise have been. This distinction is important because it has implications for whether one's ontology counts as naturalistic. ‘Spookiness’, we have seen, describes entities or properties that are not recognized by the sciences and so are immediately and invariably objectionable to the naturalist. Objective modality, on the other hand, is by no means objectionable in this way. The sciences do recognize modality, which is to say that scientific theories go beyond mere descriptions of the actual course of natural events:

Scientists never bother to formulate theories that only refer to what actually happens in the world; instead theories are always modalized in the sense that they allow for a variety of different initial conditions or background assumptions rather than just the actual ones, and so describe counterfactual states of affairs.

(Ladyman, 2004, p. 852)

Whereas no science recognizes divine intervention or extra-sensory perception, then, ‘there is a near-universal recognition that modality is central to science’ (Ismael, 2017, p. 109).<sup>14</sup> That one endorses a commitment to objective modality does not therefore provide sufficient reason to revoke one's naturalist credentials. Indeed, for many such a commitment follows directly from their naturalism. That is to say, if the sciences support reliable counterfactual generalizations concerning what *would* happen *were things thus and so*, then it stands to reason that they ‘reveal [something] about the modal substructure behind the phenomena’ (Ismael, 2017, p. 109) and thus that an appropriately naturalistic ontology ought to involve commitment to such substructure.

Granted, there are forms of objective modality that sit uncomfortably with a commitment to naturalism. Take the semantics of modal claims (or the semantics of philosophical claims about modality) literally, for example, and we appear to commit ourselves to a massively inflationary ontology of infinite real possible worlds.<sup>15</sup> As Ismael observes, however, ‘it has never been clear what these [possible worlds] are, or how we could know about them’ (2017, p. 109). Indeed, such worlds might very well qualify as ‘spooky’ in the sense outlined above.<sup>16</sup> Accordingly, those who endorse a commitment to objective modality on naturalist grounds typically seek to describe such modality as somehow encoded *within* the actual world:



there is among many a desire to reject metaphysical commitment to non-actual, possible worlds. To satisfy that desire while preserving scientific practice, one needs an account of modality that makes modality immanent in the actual world, i.e., one that does not take the semantics of modal belief at face value.

(Ismael, 2017, p. 109)

The infinitely inflationary metaphysics of modal realism notwithstanding, then, the twofold point remains: not only is some commitment to objective modality perfectly compatible with naturalistic ontology, but commitment to an immanent form of objective modality is (for many) an essential feature of one's naturalism.

So why think that Deleuze shares such a commitment, especially in light of his aforementioned critique of the modal category of possibility? Well, his entire positive project can be characterized as an exercise in the metaphysics of modality. He might not approach the subject in the same way and with the same vocabulary as the contemporary analytic metaphysician, but it is not for naught that one commentator describes his philosophical vision as that of a 'purely modal [...] universe' (Smith, 2012, p. 37). Throughout his writings, Deleuze remains obsessed with novelty and creativity, with expressions of power, with capacities to affect and be affected, and with what bodies can do. In a word, with *difference*. And any philosophy of difference—that is, any philosophy that attributes to difference a logically and ontologically primary status and according to which the world, on its most basic description, can and does continuously differ or prove to be otherwise—just is an account of a radical and metaphysically primitive form of objective modality. More to the point, and as already mentioned, Deleuze assigns to philosophy the task of rejecting transcendence and of articulating a wholly immanent account of the world or of immanence as such.<sup>17</sup> He admits of no purely intelligible domain of Platonic forms nor any other substance or mode of being external to or beyond the sensible. Whatever world there is, for Deleuze, is the *only* world. His account of objective modality must therefore attribute such modality to that world. Not only is Deleuze committed to a form of objective modality, then, but he shares in our contemporary philosopher of science's commitment to an *immanent* form of objective modality. That is, to a form of modality that is part of or encoded within the actual (or in Deleuze's idiom the 'real') world.

It is precisely this kind of modality, I argue, that Deleuze describes with his talk of 'pure events, abstract machines and other kinds of virtual reality'. For example, Patton observes that Deleuze, adopting resources from the respective histories of mathematics and philosophy, describes the virtual in terms of 'differentials of virtual Ideas' (2016, p. 352). What he fails to acknowledge, however, is that such descriptions are invariably modal. 'Not only is the differential relation the pure element of potentiality' (1968/1994, p. 47), for Deleuze, but virtuality and potentiality (a modal notion) are frequently explicitly identified with one another: 'the potentiality of the Idea, its determinable virtuality' (1968/1994, p. 201), 'a potential or a virtuality' (1968/1994, p. 183), 'a virtuality, a potentiality' (1968/1994, p. 185), 'a potential or virtual object' (1968/1994, p. 212), and so on.<sup>18</sup> The same can be said for the machinic ontology of *A Thousand Plateaus*. Indeed, Patton himself observes (though not in our terms) that Deleuze and Guattari present a radical and sophisticated account of objective modality, describing their related notion of 'absolute deterritorialization' as the 'immanent source of transformation, the reserve of freedom or movement in reality' (2016, p. 354)—that is, as the objective modal pre-condition for change, novelty, or the world's ability to be otherwise.

Consider also Deleuze's treatment of the Lucretian *clinamen*, one of those 'other kinds of virtual reality' mentioned by Patton (2016, p. 352). This treatment takes place in the context of Deleuze's positive account of the world as fundamentally differential or relational. Nature, he claims, is structured by 'Ideas', understood as 'multiplicities' or 'system[s] of multiple, non-localisable connections between differential elements [...] incarnated in real relations and actual terms' (1968/1994, p. 183). He provides three (admittedly brief and speculative) 'examples', each of which engages with some aspect of the history of philosophy or the sciences and by means of which he attempts to express his view.<sup>19</sup> The first such 'example', labeled '*atomism as a physical Idea*', begins with a consideration of 'Ancient atomism' and the *clinamen* (1968/1994, p. 184). Originally postulated to accommodate free will and to explain the possibility of collisions between unidirectionally falling atoms in an Epicurean void, the *clinamen*, Deleuze



insists, 'is [in fact] by no means a change of direction in the movement of an atom, much less an indetermination testifying to the existence of a physical freedom' (1968/1994, p. 184). 'It is', rather, 'the original determination of the direction of movement, the synthesis of movement and its direction which relates one atom to another' (1968/1994, p. 184). Deleuze, in other words, criticizes the Epicurean conception of the atom for enjoying 'too much independence, a shape and an actuality' (1968/1994, p. 184). He rejects the idea that atoms are first and foremost individuals with discrete and intrinsic identity profiles between which relations obtain, claiming instead that they are relationally constituted: 'it is indeed essential that atoms be related to other atoms' (1968/1994, p. 184). Thus, it is not the case, on Deleuze's account, that the movements of atoms and their relative positions to one another in the void are modifications of or attributable to already constituted individuals. Rather, the movements or relations themselves constitute their atoms and the *clinamen*, on Deleuze's view, simply expresses this fact or such 'original determination'. Deleuze, then, is redescribing Lucretian atomism in terms of his own metaphysics of difference. That is, as a theory of physical Ideas understood as 'multiplicities of atoms' (1968/1994, p. 184).

But he also acknowledges the limits of such ancient conceptual fare and speculates as to whether 'modern atomism' might more adequately reflect his ontology. That is, he entertains the question 'whether modern atomism, by contrast, fulfils all the conditions of a structure' (1968/1994, p. 184)—Ideas or multiplicities having already been defined in structural terms: 'The Idea is thus defined as a structure' (1968/1994, p. 183). In language approaching that of contemporary physics, he appeals to those "'multiple and non-localisable connections" established between particles' (1968/1994, p. 184).

Now, precisely what Deleuze has in mind here depends upon how closely his language corresponds to that of physics and the philosophy thereof. But he might well be alluding to quantum non-locality, famously described by Einstein as 'spooky action-at-a-distance'.<sup>20</sup> The details here are technical, but observation shows that (for example) pairs of electrons in the so-called 'singlet state' always anti-correlate with respect to their 'spin'.<sup>21</sup> Once the spin value of one electron in some direction is determined, the same value for the other electron in the opposite direction is guaranteed such that the total angular momentum of the singlet state is conserved and remains zero. Crucially, such momentum is conserved even when these electrons are separated by great distances. Divorce a pair of singlet-state electrons from one another and transport them to opposite ends of the earth, for example, and they still anti-correlate in the relevant way. Now, *prima facie* this situation seems unmysterious. My shoes anti-correlate in a putatively analogous way (left or right). And if I box up each shoe and mail one to you and keep the other it is not at all surprising that they retain such anti-correlation. But the subatomic situation differs in that sophisticated experimentation shows that our singlet-state electrons, unlike my shoes, do not 'start out' in any particular configuration and are thus not predisposed to anti-correlate in any *specific* way. To repair our analogy, the situation would have to be such that each shoe in each box was neither definitely the left nor definitely the right but somehow indeterminate and equally likely to be one or the other. Such indeterminacy would remain until someone opened their box, thereby revealing either the left or the right and thus simultaneously determining the contents of the other's box. Again, crucially, the shoe in your box might very well be the left or it might very well be the right; this is not determined at the moment of packaging. And again, crucially, our two 'shoes' will always anti-correlate. As Maudlin remarks: 'by observing how one electron behaves, one can predict with perfect accuracy how the other will (or has)' (2019, p. 26). Hence Einstein's 'action-at-a-distance': singlet-state electrons are somehow able to anti-correlate with one another without the particulars of their anti-correlation having been determined in advance, thereby suggesting some kind of non-local interaction. Once the relevant state of one electron is determined, this determination is 'communicated', so to speak, instantaneously across arbitrary distances to its partner, which assumes the anti-correlating state.

Plausibly, then, it is this phenomenon of quantum non-locality to which Deleuze refers with his appeal to "'multiple and non-localisable connections" established between particles' (1968/1994, p. 184). That said, Deleuze's intentions here are unimportant. What matters is that the conceptual machinery represented by his idiosyncratic terminology (and this includes his anachronistic discussion of Epicureanism and the Lucretian *clinamen*) is in fact recognized by physical theory and so cannot qualify as 'spooky' or non-naturalistic in the way Patton claims. We need not

extend ourselves far beyond Deleuze's initial speculation, for instance, to designate specific features of his ontology as referents for the relevant physics. He describes an Idea as an 'n-dimensional, continuous, defined multiplicity' (1968/1994, p. 182). By 'dimensions', he means those 'variables or co-ordinates upon which a phenomenon depends' (1968/1994, p. 182) and, in our quantum context, such variables are the relevant parameters of the singlet state. By 'continuity', he means that 'set of relations between changes in these variables' (1968/1994, p. 182). In our case, this is the relevant set of anti-correlation relations. And by 'definition', he means those 'elements reciprocally determined by these relations' (1968/1994, pp. 182–183). In our case, the specific observable spin values of our particles. Deleuze explicitly states that there are Ideas 'which correspond to mathematical relations and realities' or to 'physical laws and facts' (1968/1994, pp. 183–184) and so it would seem that our quantum mechanical experimentation reveals an Idea of just this sort, one which can be expressed mathematically (or in Dirac notation) as such:

$$\frac{1}{\sqrt{2}}(|\uparrow\downarrow\rangle - |\downarrow\uparrow\rangle)$$

Deleuze emphasizes that any candidate Idea found in this domain ought to enjoy the same modal character required, we have seen, of any Idea on his account. He therefore invites us to explore 'the character of the "potentially" expressly attributed to these particles' (1968/1994, p. 184).<sup>22</sup> Much like his and Guattari's notion of absolute deterritorialization, then, and much like the key concept of virtuality, Deleuze's treatment of the Lucretian *clinamen*, once contextualized appropriately, does in fact appear to refer to a kind of objective modality that is recognized by the sciences and is thus perfectly compatible with a form of ontological naturalism.

### 3.3 | Ansell Pearson and Protevi on ontological naturalism

We can now turn to Ansell Pearson and Protevi, for whom naturalistic ontology is understood in terms of varying strengths of physicalism. Their 'weak' version 'merely denies the existence and explanatory power of supernatural entities', thereby allowing 'entities and states emergent from and irreducible to the physical' (2016, p. 34). Call this 'emergentism'. Their 'strong' version is 'nonreductive physicalism', which on their view allows for 'vital, social, or mental properties of physical events, but not vital, social, or mental states, [...] thereby asserting a property dualism linked to a substance monism' (2016, p. 34). Their 'superstrong' version is just '(reductive) physicalism', according to which 'only physical entities exist' (2016, p. 34).<sup>23</sup> Much like accounts based on causal closure, however, physicalism thus understood also fails to reflect the commitments of the sciences—unsurprising, given that debates surrounding physicalism 'are striking for the near total absence of reference to current scientific theories or results' (Ladyman et al., 2007, p. 39).

Consider the following two arguments. The first concerns the idea of physicalism as an exclusively ontological thesis. If physicalism is supposed to demarcate naturalistic ontology, then it should be motivated by what the sciences actually say. As Ladyman et al. observe: 'There is a tension between the goal of providing a naturalist defence of physicalism, and that of making physicalism an ontological thesis but not an epistemological one' (2007, p. 40). Such motivation 'will consist in a catalogue of explanatory—that is, epistemological—successes' (2007, p. 40). And yet, such success cannot imply physicalism because many sciences other than physics enjoy such success. The sciences yield reliable generalizations and predictions about migration patterns and financial markets, just as they do about electrons and quarks. Hence

a responsible naturalist who defers to science as it stands in matters of belief formation will find herself ontologically committed to all sorts of entities and properties that aren't straightforwardly physical, in the sense of being studied as such by physicists.

(2007, p. 40)

At the very least, then, Ansell Pearson and Protevi's 'superstrong' version of ontological naturalism, or their 'reductive' physicalism, provides an unsuitable demarcation criterion for naturalistic ontology.

Our second argument concerns physicalist (and emergentist) ontology itself. Physicalism assumes a kind of asymmetry to the world. As Schaffer observes, the physicalist (among others)

starts with (a) a hierarchical picture of nature as stratified into levels, adds (b) an assumption that there is a bottom level which is fundamental, and winds up, often enough, with (c) an ontological attitude according to which the entities of the fundamental level are primarily real, while any remaining contingent entities are at best derivative, if real at all.

(2003, p. 498)

We observe compositional or mereological relations between sand and sandcastles, bricks and walls, people and communities, foodstuff and sandwiches and we extrapolate a metaphysics of sub-microscopic entities that occupy some ontologically foundational or fundamental position either within a cascading series of asymmetrical determining relations between parts and wholes or within a hierarchy of 'levels',<sup>24</sup> often associated with the divisions between scientific disciplines—the physical, the biological, and the neurological, to borrow Ansell Pearson and Protevi's own examples (2016, p. 34). And yet, despite the apparent naturalism of this view, it lacks scientific justification. Indeed, the sciences recommend a more egalitarian attitude toward our metaphysical commitments.

Consider physicalism of the 'part-whole' variety. This is the view that all macrophysical entities 'are asymmetrically determined by their microscopic physical parts and the microscopic physical laws that apply to those parts' (Hüttemann & Papineau, 2005, p. 34). And consider also, to borrow Hüttemann and Papineau's example, a classical mechanical system that obeys the law of conservation of mass such that the total mass of that system ( $m_4$ ) is equal to the combined masses of its subsystems ( $m_1, m_2, m_3$ ). Thus, our law (M) will be expressible as  $m_1 + m_2 + m_3 = m_4$  (see 2005, pp. 36–37). Clearly, the mass of the three subsystems determines the total mass of the system. But the direction of this determining relation goes both ways. Indeed, any three of our  $m$  values is sufficient to determine any fourth. 'The law (M) that governs the relation of parts and wholes thus seems to imply no asymmetric determination of the macromass, but simply a mutual dependence of parts and wholes' (2005, pp. 36–37). As with Redhead above, the physics reveals only reciprocal determining relations. We have no cause to privilege the putatively basic constituents of reality over the things they compose.

Against 'levels' physicalism, the sciences deny the requisite 'fundamental framework within which to describe the levels against which everything else exists' (Ladyman et al., 2007, p. 179). In other words, the idea that the world comes in levels requires some metric by means of which their relations can be understood. And yet there is little evidence to suppose that any such metric exists. The most plausible candidate is size: the lowest or fundamental level (if there is such a thing) consists of subatomic particles whereas the higher levels consist of increasingly large and complex entities, ranging from atoms and single-celled organisms to whales and tectonic plates and galaxies. As Ladyman et al. point out, however, 'contemporary physics takes very seriously the idea that spacetime itself is emergent from some more fundamental structure' (2007, p. 23).<sup>25</sup> Size, or 'the structure of space and the metric used to measure length' (2007, p. 179), therefore fails to qualify as an appropriate backdrop against which levels of the world might be arranged. Indeed, the sciences suggest that there is no such backdrop. Since the advent of quantum theory, the world simply fails to exhibit any basic character common to all domains of inquiry:

The microworld is not just a smaller version of the macroworld in the sense that the laws of nature seem to care about length scales, energy scale, and velocity. Quantum physics and putatively more fundamental theories describe realms to which the metaphysics of everyday things is not applicable.

(Ladyman, 2017, p. 158).

This fact leads some philosophers of science, such as Ladyman et al., to endorse the ‘scale relativity of ontology’, according to which ‘claims about what (really, mind-independently) exists should be relativized to (real, mind-independent) scales at which nature is measurable’ (2007, p. 200).<sup>26</sup> The world, it seems, is lens-like: just as I cannot bring both nearby and distant objects into focus within a single field of vision, neither can the respective ontologies of quantum mechanics and biology, for example, be held within one and the same conceptual horizon. Thus, ‘at the quantum scale there are no cats; at scales appropriate for astrophysics there are no mountains; and there are no cross-elasticities of demand in a two-person economy’ (Ladyman et al., 2007, p. 199).

If ontologies at different scales are incomparable in the way the sciences suggest, then the hierarchical commitments of physicalism collapse or ‘flatten out’ into a more egalitarian schema. ‘Good generalizations at any scale deserve the same scientific respect’ (2007, p. 51). Our second argument therefore reveals the basic conceptual framework of ontological physicalism to be non-naturalistic and thus unsuitable for demarcating naturalistic ontology. The sciences simply do not support the idea that the world is stratified into asymmetrical determining relations, be they inter-level relations of reduction or supervenience or intra-level relations between microphysical parts and macrophysical wholes.<sup>27</sup> The same holds for emergentism, which ‘warrants its name because it holds that “higher” levels of organization “emerge” indeterminably out of “lower” level ones’ (Ladyman et al., 2007, p. 56) and thus still depends upon the basic architecture of the levels metaphor. If our metaphysical commitments are indeed to be scientifically informed, then not only should we commit ourselves to all kinds of non-physical entities (as per our first argument), but we should also adopt an egalitarian attitude toward those commitments.

Note that Deleuze shares this egalitarian attitude. Endorsing the Duns Scotian doctrine of the univocity of being, he claims that ‘all things are in absolute proximity, and whether they are large or small, inferior or superior, none of them participates more or less in being, nor receives it by analogy’ (1968/1994, p. 37). Similarly, in *A Thousand Plateaus*, Deleuze and Guattari express their preference for flat ‘rhizomatic’ structure over hierarchical ‘arborescent’ organization (1980/1987, pp. 3–25):

there is no lesser, no higher or lower, organization [...] a semiotic fragment rubs shoulders with a chemical interaction, an electron crashes into a language, a black hole captures a genetic message, a crystallization produces a passion, the wasp and the orchid cross a letter...

(1980/1987, p. 69)

The just-cited passage, to my mind, though no doubt written in a more provocative style, expresses the same sentiment as Ladyman et al. when they write: ‘Prices, neurons, peptides, gold, and Napoleon are all real [...] in the same unqualified sense as quarks, bosons, and the weak force’ (2007, p. 300).

Close engagement with contemporary philosophy of science thus casts new light on Deleuze’s philosophy of difference and its relation to the sciences. Deleuze’s failure to adhere to a causal-closure account of the world does not make him non-naturalistic because such an account does not adequately demarcate naturalistic from non-naturalistic ontology. Similarly, naturalism ought not to be associated with a hierarchical picture of reality that is antithetical to Deleuze’s own metaphysical commitments. Rather, engagement with the relevant literature shows that the sciences (on some accounts, at least) do in fact support a ‘flat’, scale-relativistic ontology of the kind attributable to Deleuze.<sup>28</sup> If one wants to adjudicate on the question of Deleuze’s naturalism, then, one cannot ignore contemporary developments in the philosophy of science. And if one intends to claim that Deleuze’s ontology is non-naturalistic, then one must present some feature of his ontology for which no recognizably naturalistic analogue exists in the philosophy of science literature. In so far as Deleuze and Guattari’s notion of absolute deterritorialization, Deleuze’s engagements with ancient atomism, and his key concept of virtuality can all be cashed out in terms of an attempt to articulate a radical form of objective modality, however, Deleuze’s metaphysics of difference does indeed appear to be consistent with a more scientifically authentic account of ontological naturalism.

### 3.4 | Methodological naturalism

The rest of this essay is concerned with Deleuze and methodological naturalism. Recall the tension we observed between using physicalism as a guide for naturalism and understanding physicalism as an ontological, but not an epistemological or methodological, doctrine. This tension extends to naturalism itself. If naturalism is not about the blind, speculative harmony of one's metaphysical commitments with those of the sciences (and it is hard to see how such a view would qualify as a form of naturalism), then it must be scientifically *motivated*. Thus, any naturalism proper must include a methodological component. Before we turn to Deleuze's actual engagements with science in order to determine whether they are methodologically naturalistic, though, we must (as we have just done with ontological naturalism) establish an appropriate sense of what counts as methodologically naturalistic philosophy—and we can do so by again using recent work in Deleuze studies as a foil.

As with their account of ontological naturalism, Ansell Pearson and Protevi present three versions. Their 'weak' version 'asserts a compatibility between the goals and methods of philosophy and natural science, so that they can and should inform each other, even though philosophy maintains its specificity and independence from science' (2016, p. 34). Their 'strong' version 'asserts a continuity between philosophy and natural science, so that philosophy has no real independence' (2016, p. 34). And their 'superstrong' version they describe as 'scientism', according to which 'only natural science produces meaningful statements, credence-worthy beliefs, and so on' (2016, p. 34). Patton similarly describes methodological naturalism as the belief that 'natural science is a privileged if not the only form of knowledge and that, to the extent that philosophy aims to produce knowledge, it is continuous with science' (2016, p. 351). 'Weaker versions [...] might allow for distinct philosophical knowledge and ways of knowing', on his account, 'so long as these do not conflict with scientific knowledge' (2016, p. 351).

Again, we encounter the assumed asymmetry of the physicalist worldview, this time privileging 'natural' science over (presumably) social science. That said, the question of which sciences warrant deference is perhaps not as pertinent here as the character of that deferential attitude itself. That is, its scope and limits. And in this respect it seems as though only what Ansell Pearson and Protevi describe as 'strong' methodological naturalism (qualified to include *all* successful scientific theories) is supported by science.

What they describe as 'scientism', for example, resembles logical positivism more than any position taken seriously by philosophers of science today. Even Ladyman et al., who identify as 'radical methodological naturalists' (2007, p. 27) and 'admire science to the point of frank scientism' (2007, p. 61), reject the claim that *only* science produces meaningful statements and credence-worthy beliefs.<sup>29</sup> Why? Well, because even they maintain a place for a distinctively philosophical (that is, metaphysical) form of inquiry. The sciences tend toward unified theoretical descriptions of phenomena: light, electricity, and magnetism are unified in electrodynamics; Galileo's law of free fall (examined above) and Kepler's laws of planetary motion are unified by Newton's inverse-square law of gravitation; the Boyle-Charles law, Graham's law, and specific heat capacities are unified by the kinetic theory of gases; and the wave and corpuscular theories of light are unified in quantum mechanics.<sup>30</sup> Thus, 'one of the important things we want from science is a relatively unified picture of the world' (2007, p. 27). Articulating a picture of the world that is *maximally* unified, or 'critically elucidating consilience networks across the sciences' (2007, p. 28), thus becomes the task of an appropriately scientifically informed metaphysics—a task shared by no particular science.<sup>31</sup> What Ansell Pearson and Protevi describe as 'scientism' therefore proves to be non-naturalistic because the sciences themselves necessitate a domain of inquiry that is not (or at least not straightforwardly) itself a science.

Patton and Ansell Pearson and Protevi's 'weak' methodological naturalism concerns the mere compatibility of philosophy with science and thus the possibility of non-scientific sources of metaphysical knowledge. It thus lies outside the scope of this essay, which excludes Deleuze's engagements with art, literature, cinema, the history of philosophy, and so on. Granting that we are concerned only with the relation between Deleuze's engagements with the sciences and his own philosophical claims, then we can judge that relation to be methodologically naturalistic if those claims result from some attempt to describe how the world must be such that the engaged sciences are reconcilable into a single metaphysical worldview.

## 4 | DELEUZE AND SCIENCE

Though more can be said about methodological naturalism, especially with respect to the status of physics,<sup>32</sup> we are now in a position to provide some assessment of whether Deleuze's engagements with the sciences are naturalistic in this sense. Before we examine Deleuze's actual engagements with science, though, let us first examine how the question of methodological naturalism itself emerges in Deleuze's philosophical writings.

### 4.1 | The metaphysics science needs

In an interview exchange with Arnaud Villani, Deleuze states: 'I feel that I am Bergsonian—when Bergson says that modern science has not found its metaphysics, the metaphysics it needs. It is that metaphysics that interests me' (1999/2007, p. 41).<sup>33</sup> We can see why commentators who emphasize Deleuze's engagements with science and mathematics might seize upon this remark to defend their interpretative approach.<sup>34</sup> But this statement is ambiguous: it underdetermines Deleuze's view in a crucial way. What, after all, does it mean for us to be interested in 'the metaphysics science needs'? What is the implied relationship here between metaphysics and the sciences?

Here are two interpretations. On the first, the sciences fail to describe what the world is really like. They either make no such attempt or they articulate or support a metaphysics that is faulty in some way. Philosophers are therefore tasked with doing metaphysics properly and with accounting for the misrepresentative claims of science. On the second interpretation, the sciences do yield information about what the world is really like, but they lack either the resources or the prerogative to articulate their own ontology. Philosophers are therefore tasked with teasing out this ontology in the appropriate way. The distinction here is that between the metaphysics science lacks and the metaphysics science warrants. On the first interpretation, Deleuze is non-naturalistic in the relevant sense; on the second, he defers to science in a way that may yet prove to be naturalistic.

So how do we break this underdetermination in favor of one interpretation or the other? The obvious approach is to follow the reference to Bergson, for whom science fails to reflect what is, on his account, the fundamentally 'mobile' or 'durational' character of reality: 'science cannot deal with time and motion except on condition of first eliminating the essential and qualitative element—of time, duration, and of motion, mobility' (1889/2004, p. 115). Bergson sought to articulate a proper metaphysics of duration, one that could more accurately represent the basic character of reality while also accommodating and explaining the putatively misrepresentative claims of the sciences: 'philosophy will have to follow science [...] so as to place atop scientific truth a different kind of knowledge, one that will be called metaphysical' (1907/2023, p. 178). By referring to Bergson in the above passage, then, Deleuze appears to be endorsing our first interpretation.

But a closer reading of his exchange with Villani complicates this suggestion. Consider Villani's initial prompt, in which he asks whether the philosophy elaborated in *A Thousand Plateaus* (recently published at time of interview) might be 'transposable' into mathematics or biology: 'The conclusion of *A Thousand Plateaus* consists in a topological model which is radically original in philosophy. Is it transposable into mathematics, biology?' (1999/2007, p. 41). Deleuze prefaces his 'Bergsonian' reply with the following remark: 'You ask if a mathematical or biological transposition is possible. No doubt it is the other way around' (1999/2007, p. 41). What is the significance of this prefatory remark and how does it complicate our attribution of a straightforwardly Bergsonian or non-naturalistic status to Deleuze? Well, Villani's prompt concerns a particular order of explanation. He is asking whether the concepts articulated in *A Thousand Plateaus* might be applicable to, help us make sense of, or explain mathematics or biology. In this respect, it is Villani who is Bergsonian in the sense that he regards the order of explanation here as running from philosophy or metaphysics to the sciences. Deleuze, however, claims the reverse. He is concerned not with the transposability of philosophical concepts into mathematics and biology but with the transposability of mathematical and biological theories or hypotheses into philosophy. 'How might mathematics and biology help us to make sense of the world on a broader philosophical or metaphysical register?', we can imagine Deleuze asking. Far from endorsing

our Bergsonian interpretation, then, he in fact appears to be endorsing our second, potentially naturalistic, interpretation.

This claim fits with other remarks, made by Deleuze in his preface to the English translation of *Difference and Repetition*, concerning the dependence of philosophy upon science (and art):

philosophy obviously cannot claim the least superiority, but also creates and expounds its own concepts only in relation to what it can grasp of scientific functions [...]. [...] it can advance itself only by forming properly philosophical concepts from a given function [...].

(1968/1994, p. xvi)

Echoing his response to Villani, he continues: 'It is in this sense that we tried to constitute a philosophical concept from the mathematical function of differentiation and the biological function of differentiation' (1968/1994, p. xvi). Again, the sciences provide valuable *input* for metaphysical deliberation; they do not present errors to be explained away by philosophy. For now at least, then, our underdetermination remains unbroken. There is textual evidence to support both interpretations of Deleuze's statement of interest in the metaphysics science needs.

## 4.2 | Two levels of engagement

Though he does not cite this statement of interest, nor does he employ the language of naturalism, May (2005) provides some valuable exegesis and a helpful descriptive vocabulary that, with slight modification, allows us to identify our aforementioned underdetermination in Deleuze's actual engagements with science.

May identifies 'two levels' to these engagements (2005, p. 239). The first is Deleuze and Guattari's sustained discussion of science and its relation to philosophy in *What is Philosophy?*. Here they embrace Bergson's influence and in particular his descriptive machinery of 'mobility' and 'immobility' or 'speed' and 'slowness'. Bergson, recall, claims that the ultimate nature of the world is best characterized as 'duration', which is his term for the ineliminably flowing or fleeting quality of time and motion. 'This reality is mobility. There do not exist *things* made, but only things in the making, not *states* that remain fixed, but only states in process of change' (1903/2007, p. 203). Duration, which is the proper object of metaphysical inquiry on Bergson's account, is described as a 'continuity of flow' (1903/2007, p. 175), or as 'pure mobility' (1903/2007, p. 177), whereas science is a 'slowing down' (1903/2007, p. 196), a mode of analysis which 'congeals' this continuous flow by means of 'fixed, distinct and immobile concepts' (1903/2007, p. 209). Crucially, for Bergson, mobility cannot be reconstructed out of immobility. Achilles's sprint is more than the infinite sum of interstitial states he occupies along his way. Hence Bergson's commitment to a non-naturalistic order of explanation between metaphysics and the sciences (as he understands them). The sciences can be conceived as enacting some discretizing procedure upon duration in order to produce scientific knowledge, resulting in a worldview of discrete states and entities from which a proper metaphysics of duration cannot be recovered: '*fixed concepts can be extracted by our thought from the mobile reality; but there is no means whatever of reconstituting with the fixity of concepts the mobility of the real*' (1903/2007, p. 204). In *What is Philosophy?*, Deleuze and Guattari present a near-identical descriptive and conceptual package. Philosophy, on their account, trades in 'concepts', which are defined as '*the inseparability of a finite number of heterogeneous components traversed by a point of absolute survey at infinite speed*' (1991/1994, p. 21). Obviously, this definition is somewhat opaque. But its Bergsonian provenance makes it easier to decode. By attributing to concepts the ability to 'traverse heterogeneous components at infinite speed', Deleuze and Guattari are simply making a claim about the ability of philosophical inquiry to recognize and reflect what they regard as the irreducibly mobile, relational, or differential character of the world, its 'pure and simple *variations*' (1991/1994, p. 20). Scientific analysis, on the other hand, trades in 'functions', which they describe (again taking their cue from Bergson) as a '*fantastic slowing down*' (1991/1994, p. 118). Incorporating Deleuze's earlier language of the actual and the virtual (which, incidentally, Deleuze inherits from Bergson), they



write: 'By retaining the infinite [infinite speed], philosophy gives consistency to the virtual through concepts; by relinquishing the infinite, science gives a reference to the virtual, which actualizes it through functions' (1991/1994, p. 118). Recall that 'actuality' for Deleuze describes the domain of discrete individuals and states of affairs, whereas 'virtuality' describes the domain of difference in itself. By affiliating science with the actual, then, Deleuze and Guattari foreclose the possibility of genuinely scientific contact with the ultimate nature of the world. Just like Bergson, they foreclose the possibility of genuinely scientific contributions to metaphysical knowledge.

May's second level is distributed across Deleuze and Deleuze and Guattari's many references to actual bits of science and mathematics. These are found throughout earlier works, most notably *Difference and Repetition*, *Anti-Oedipus*, and in the third chapter of *A Thousand Plateaus*. Here we encounter a different kind of engagement with science. Consider, for instance, Deleuze's appeals to the gradient-based embryological theories of the 1930s–1940s.<sup>35</sup> Of particular interest to him are accounts of 'morphogenesis', the process through which the three-dimensional structure of an animal's body is generated by means of 'morphogenetic' motions or the layering or folding of cellular material within an egg.<sup>36</sup> Importantly, the theories upon which Deleuze fastens claim such motions to be induced and determined by gradients. That is, differentials in temperature or chemical concentration. Deleuze therefore identifies within such theories an ontology of fundamental intensive relations (the relevant gradient differentials within an egg) and discrete or extensive individuals (the animal body itself and its individual parts) that are determined and constituted by such relations:

the organic parts are induced only on the basis of the gradients of their intensive environment [...]. Throughout, intensity is primary in relation to organic extensions [...]. Notions such as 'morphogenetic potential', 'field-gradient-threshold' put forward by Dalcq, which essentially concern the relations of intensity as such, account for this complex ensemble.

(1968/1994, p. 251)

Here Deleuze appears to be extracting a general metaphysics of intensive difference from his engagement with embryology. 'The world is an egg' (1968/1994, p. 251), he writes, extending this embryological ontology into a global ontology of intensive difference.<sup>37</sup> In contrast to the Bergsonian order of explanation exhibited in *What is Philosophy?*, then, this second level of engagement exhibits a more deferential attitude toward the sciences. Hence, our earlier underdetermination can be identified with the apparent irreconcilability of these two levels identified by May.

More to the point, this second level of engagement qualifies as methodologically naturalistic according to the criterion established in our previous section. That is to say, on this level Deleuze extracts the same unificatory metaphysics of difference from multiple engagements with different scientific domains. As May so helpfully makes clear, such domains include (but are by no means limited to): Jacques Monod's analysis of allosteric enzymes (Deleuze & Guattari, 1972/1983, pp. 288–289, 328; May, 2005, pp. 245–246), Darwin's theory of evolution and geology (Deleuze & Guattari, 1980/1987, pp. 39–74; May, 2005, pp. 249–251), and the mathematics of the calculus (May, 2005, p. 247).

Consider Deleuze and Guattari's references to geology, for example. Here they derive the same ontology of intensive difference as that derived from embryology, though this time from claims about intensive flows of magma or sediment that stratify and striate themselves into extensive formations by means of differentials in temperature and pressure:

the Earth [...] is permeated by unformed, unstable matters, by flows in all directions, by free intensities or nomadic singularities, by mad or transitory particles. [...] there simultaneously occurs upon the earth a very important, inevitable phenomenon that is beneficial in many respects and unfortunate in many others: stratification. Strata are Layers, Belts. They consist of giving form to matters, of imprisoning intensities or locking singularities into systems of resonance and redundancy...

(1980/1987, p. 40)

Similarly, and as we see in more detail below, in his engagements with calculus Deleuze identifies an appropriate descriptive machinery for a metaphysics of fundamental difference. As May observes, Deleuze ‘sees in the differential an entire ontology of difference that can actualize itself into various functions and, consequently, specific curvilinear patterns’ (2005, p. 274). Again, this mode of engagement conforms to our account of methodological naturalism. Deleuze appears to be consulting the specific ontologies of different local scientific domains and extrapolating a global ontology of fundamental difference. As May himself remarks toward the end of his own account: ‘we have ranged over biology, microbiology, mathematics, and chemistry. And yet a single ontological picture has emerged’ (2005, p. 249).

The question of Deleuze’s naturalism therefore becomes the problem of reconciling his two levels of engagement with the sciences. On the one hand, Deleuze adopts a Bergsonian or non-naturalistic attitude; on the other, he defers to the sciences when articulating his metaphysics in a way consistent with methodological naturalism. How do we make sense of this fact? In what follows we examine a prominent interpretative strategy for resolving this issue in favor of a non-naturalistic interpretation of Deleuze’s philosophical thought. I highlight its limitations before drawing upon Deleuze and Guattari’s distinction between ‘major’ and ‘minor’ science, which I argue presents us with a solution in favor of a more naturalistic interpretation.

## 5 | DELEUZE’S ‘NON-NATURALISM’

May attempts to reconcile our two levels by reading *What is Philosophy?* as the authoritative account of the role of the sciences in Deleuze’s thought. On his account, Deleuze’s first level of engagement with science is his only genuine engagement *with science*:

In the second level of engagement, Deleuze is not referring to science *as science*; he is not offering us a view of science that either conforms to or confirms his own philosophical project. He is, instead, appropriating and often reworking scientific themes for his own philosophical purposes.

(2005, p. 239)

In his own way, then, May claims a non-naturalistic role for science in Deleuze’s philosophical thought. *What is Philosophy?* definitively states the relationship between philosophy and science and so any apparent naturalism encountered elsewhere is really just some modification of that relationship. As May puts it, this time adopting the Bergsonian idiom of *What is Philosophy?*:

the incorporation of science into Deleuze’s work is an attempt to “speed up” scientific viewpoints by offering them an ontological perspective that draws them “out of themselves” and brings them into contact with pure difference, difference in itself.

(2005, p. 254)

Though they do not cash out Deleuze’s scientific references in terms of our two levels, other commentators also adopt the interpretative strategy of privileging *What is Philosophy?* as the definitive statement of Deleuze’s views on science. Patton, for example, regards this text as ‘a more comprehensive account’ (2016, p. 355) of the relation between philosophy and science and uses it as a principal point of reference in his own argument for Deleuze’s non-naturalism (2016, pp. 350–351). Similarly, though she does not engage with the question of naturalism, Mader’s account of philosophical and scientific intensity turns on the difference between philosophical concepts and scientific functions detailed in *What is Philosophy?*: ‘Deleuze’s focus on the mathematical function is indeed essential to his understanding of the proper place and scope of science’ (2017, p. 272). Accordingly, Mader also defends a non-naturalistic interpretation, according to which the philosophical enterprise is for Deleuze ‘distinct from that of the

sciences' and on which Deleuze 'does not enjoin science to adopt the project of ontology that is philosophy's pursuit' (2017, p. 275). Such a strategy, however, fails to make adequate sense of the role of science in Deleuze's thought.

Consider May's account. What precisely is going on when Deleuze seemingly defers to the sciences in a naturalistic way? How exactly are we to understand the 'speeding-up' of science? Given May's remarks about 'reworking' and drawing scientific viewpoints 'out of themselves', one might suppose such accelerative appropriations to involve some degree of distortion or misrepresentation. And yet, Deleuze's scientific references tend to be extremely faithful. Recall his engagement with embryology—or, rather, consider the relevant source material. Deleuze presents embryologists such as Child and Dalcq as claiming intensive gradients to underlie and determine the development of animal organisms. And indeed Child does claim that 'a definite relation exists in each individual between the direction of the gradient in any axis and the physiological and structural order which arises along that axis' (1915, p. 87). Similarly, Dalcq claims that 'the development of a part or of a system automatically results from the primary gradient and field, or their immediate derivatives' (1938, p. 101). Rather than betraying exegetical violence, then, Deleuze's engagement with embryology demonstrates a high degree of fidelity to the source material.

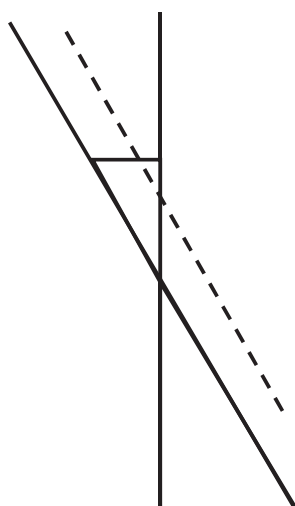
That said, Deleuze's concern with the accuracy of his scientific references is most apparent in his engagements with mathematics—and especially those found in the seminars he taught at the Université de Paris VIII—Vincennes à St. Denis.<sup>38</sup> Consider his engagement with calculus. Roughly, calculus is a tool for studying change. A little more specifically, calculus allows us to determine *instantaneous* rates of change. As Galileo's cannonball plummets back to earth, for example, it travels not at constant speed but at an increasingly higher rate until it either hits the ground or the relevant resistive forces balance out the accelerative force of gravity. This accelerative journey can be represented as a curve on a graph. And calculus allows us to determine the tangent to that curve at any point, thereby determining our cannonball's speed at any given moment on its journey. The curve (the changing value of the y-axis relative to the x-axis on our graph) is the 'primitive function' and the tangent is the 'derivative' or 'differential relation' ( $dy/dx$ ). Now, ordinarily we might think of the primitive function as primitive in a logical and ontological, as well as a nominal, sense. After all, in order for there to be rates of change (such as speed) there must first be things that are changing (our cannonball, its position, the passage of time). Deleuze, however, insists upon the reverse. On his account, it is the differential relation that is primary and that from which the primitive function is derived. This is what Duffy describes as calculus 'from the differential point of view' (2004). Evens summarizes the point nicely:

In calculus class we are presented with a function and told to differentiate it, to take the derivative or produce the differential relation. In Deleuze's rereading of the calculus, the primitive function does not precede the differential relation, but is only the ultimate result or byproduct of the progressive determination of that relation.

(2000, p. 111)

Note that Deleuze's engagement here is interpreted as a 'rereading'. Prima facie, then, by reversing our classroom intuitions Deleuze is indeed 'speeding up' calculus in the relevant distortive or appropriative way. As May writes, Deleuze 'invert[s] the relationship, moving not from function to  $dy/dx$ , but the other way around' (2005, p. 247). But this is not the case. In his seminars Deleuze pays close attention to Leibniz's 1701 essay, 'Justification of the Infinitesimal Calculus by That of Ordinary Algebra'.<sup>39</sup> Here Leibniz invites us to consider a diagram displaying two right-angled triangles whose hypotenuses and adjacent sides each fall on the same lines respectively.<sup>40</sup> Given these shared lines the triangles are similarly proportioned, each exhibiting the same ratio between its adjacent and opposite sides. These properties established, Leibniz further invites us to imagine the shared hypotenuse moving, all while 'preserving the same angle' (1701/1989, p. 545), such that one triangle grows while the other diminishes in size (see Figure 1).

Leibniz claims that even once the diminishing triangle has disappeared entirely the ratio between its adjacent and opposite sides remains identical to that between the adjacent and opposite sides of the remaining triangle. That



**FIGURE 1** Leibniz's triangles.

is to say, though the diminished sides may themselves appear equal to zero, they are not 'absolutely nothing, since they still preserve the ratio' of these remaining sides (1701/1989, p. 545). In other words, the differential relation (the relevant ratio of the diminished triangle in this case) survives the disappearance of its relata. The sides of the diminished triangle may have vanished, but they 'still have an algebraic relation to each other' on Leibniz's account (1701/1989, p. 545). As Deleuze reports: 'Like [Leibniz] says in his language, these are nothings, but they are not absolute nothings; they are nothings respectively; specifically, these are nothings, but that conserve the relational difference' (April 22, 1980).<sup>41</sup> Leibniz's own account of the calculus therefore invites us to consider a kind of relation that can survive, and is thus in some sense prior to, its terms. As Smith observes: 'The differential relation is thus not only a relation that is *external* to its terms, but a relation that in a certain sense *constitutes* its terms' (2012, p. 53).

Now, Deleuze draws on many more mathematical sources in order to articulate his view more fully. These include Weierstrass's method of analytic continuation as well as Robinson's non-standard analysis. But the twofold point here is as follows. First, Leibniz's account of the calculus provides the basic descriptive machinery for a metaphysics of fundamental difference. Hence Deleuze writes of a 'metaphysics [...] strictly immanent to the techniques of the calculus itself' (1968/1994, p. 176). Second, and as with his references to embryology, Deleuze's engagements with calculus remain faithful to the relevant source material. Indeed, it appears as though it is *our classroom intuitions* which distort the science in this case. Just as we employ a domesticated version of classical physics as a kind of pedagogical conceit when teaching physics and chemistry below the undergraduate level (think here of the 'solar system' model of the atom), so too can our classroom intuitions be understood as a domestication of the relevant mathematics. Deleuze's 'rereading' or 'inversion' of these intuitions thus proves *not* to be some distortive appropriation but rather a return to a much more faithful and literal interpretation.

Deleuze's concern with the fidelity of his mathematical references is also apparent in his seminar discussions of singularity theory. Again, he centers the discussion on a close reading of a seminal piece of mathematics, this time Henri Poincaré's qualitative approach to differential equations.<sup>42</sup> Indeed, in later seminars on the same topic he goes so far as to invite a mathematics professor (referred to in the transcripts simply as 'Marek') to these discussions in order to supervise his presentation of the material.<sup>43</sup> 'This is very important', Deleuze explains, 'because here I am dealing with things not so good from a mathematical point of view, but he's [Marek] there to correct me' (January 6, 1987). Deleuze repeatedly checks his comprehension with Marek: 'That's it, right?' (January 27, 1987) and 'it's nearly my turn to ask you certain things' (January 6, 1987) being typical examples of such interactions. He even solicits a brief lecture from Marek on the topic of singularity, which then serves as a basis for discussion for the rest of the course.<sup>44</sup> Thus, in the face of such

repeated and concerted efforts to authenticate his engagements with mathematics and the sciences, the claim that Deleuze's 'speeding up' amounts to some kind of distortion procedure becomes implausible.

So, how ought we to understand this 'speeding-up' if not as the exercise of some degree of interpretative license on Deleuze's part? Given May's claims about 'going beyond the biological to the ontological' (2005, p. 245) and about lending science 'an ontological perspective' (2005, p. 254), we might more reasonably suppose that to 'speed up' science is simply to generalize from the local domains of specific sciences to a broader ontological worldview. This seems to be exactly what is going on in the third chapter of *A Thousand Plateaus*. As May observes: 'it offers a more general ontology that brings together several [...] scientific views' (2005, p. 251). And yet, we have seen, this is just methodological naturalism! Again, the methodologically naturalistic metaphysician engages with various scientific theories and hypotheses and constructs a reconciliatory ontological framework therefrom.<sup>45</sup>

At this point, the advocate for Deleuze's non-naturalism might appeal to the following passage from *What is Philosophy?* (as do May (2005, p. 251) and Patton (2016, p. 350)): 'Philosophy does not consist in knowing and is not inspired by truth. Rather, it is categories like Interesting, Remarkable, or Important that determine success or failure' (1991/1994, p. 82). Prima facie this claim poses a significant problem for any naturalistic interpretation of Deleuze's thought. If philosophy has no regard for truth, then how can metaphysics be scientifically informed in the way the naturalist requires? In May's words: 'Science cannot provide evidence for philosophy, since philosophy is not a matter of truth; it does not seek evidence' (2005, p. 254). And yet, 'has no regard for truth', or 'is not a matter of truth', does not follow from 'is not inspired by truth'. At least some factual information is required in order to distinguish the interesting, remarkable, or important from the dull, quotidian, or insignificant. As May himself observes: 'Believing one can walk through walls does not generally result in anything interesting' (2005, p. 256, n. 53). That philosophy 'is not inspired by truth', or that truth is not the principal aim of philosophical inquiry, then, in no way entails that truth and evidence are not necessary prerequisites for the pursuit of whatever that principal aim might be (in this case, the interesting, remarkable, and important). More to the point, note that by 'Interesting, Remarkable, or Important' Deleuze and Guattari are referring to the mathematical notion of singularity. As they write earlier in *What is Philosophy?*: 'the question of philosophy is the singular point' (1991/1994, p. 11). This is the same notion of singularity studied, for example, by Poincaré in his essays on the qualitative approach to differential equations, in which he identifies various such points that Deleuze and Deleuze and Guattari go on to use as key features in their ontology.<sup>46</sup> Deleuze makes this mathematical provenance explicit: 'the notion of singularity [...] or singular point is a notion of mathematical origin that appeared with the beginnings of the theory of functions' (January 27, 1987). Thus, he makes no philosophical appeal to the 'Interesting, Remarkable, or Important' that is not already prefigured by, or indeed derived from, mathematics and science. Far from giving us reason to deny Deleuze's naturalism, then, appeals to this passage from *What is Philosophy?* actually testify to a more naturalistic interpretation.

We have so far surveyed some weaknesses internal to this non-naturalistic interpretative strategy, which foregrounds *What is Philosophy?* as the authoritative account of Deleuze's views on science. In our attempts to make sense of what precisely this strategy involves—that is, how this strategy parses Deleuze's second level of engagement with the sciences—we find ourselves pushed repeatedly in the direction of naturalism. We see that Deleuze cares about the accuracy of his discussions of scientific theories; that he extracts a common ontological framework from each of his scientific engagements; and that even one of his and Guattari's most pronounced putative statements of non-naturalism is in fact derived from such engagements. Still, there remains a greater external challenge to this interpretative strategy: namely, that it fails to accommodate Deleuze and Guattari's distinction, found in the 'Nomadology' chapter of *A Thousand Plateaus*, between 'major' and 'minor' science.

## 6 | DELEUZE'S 'MINOR' NATURALISM

Surprisingly, Deleuze and Guattari's distinction between 'major' (or 'royal') and 'minor' (or 'nomad') science is not often discussed in the context of Deleuze's views on science.<sup>47</sup> And yet it has important implications for our

understanding of those views. Crucially, major science exhibits the same basic character as that exhibited by what Deleuze and Guattari call 'science' in *What is Philosophy?*. Just as the scientific function, we have seen, is concerned with fixity and stability, or with producing a 'freeze-frame' or 'Slow-motion' (1991/1994, p. 118) of our continuously varying world in an effort to establish 'constants or limits' (1991/1994, p. 205), so too is major science concerned with 'extracting constants' (1980/1987, p. 369). The major-scientific approach, on Deleuze and Guattari's account, 'is inseparable from a "hylomorphic" model implying both a form that organizes matter and a matter prepared for the form' (1980/1987, p. 369). In other words, major science represents the world as some inert and malleable content upon which forms and order are imposed by eternal and transcendent laws: 'The search for laws consists in extracting constants, even if those constants are only relations between variables [...]. An invariable form for variables, a variable matter of the invariant: such is the foundation of the hylomorphic schema' (1980/1987, p. 369).

Minor science, on the other hand, exhibits the same basic character as that exhibited by philosophy in *What is Philosophy?*. Just as philosophical concepts describe the fundamentally differential nature of the world, or its 'pure and simple variations' (1991/1994, p. 20), so too is minor science concerned with 'continuous variation' (1980/1987, pp. 363, 365) or with that 'objective zone of fluctuation that is coextensive with reality itself' (1980/1987, p. 373). The minor-scientific approach is associated not with a hylomorphic but a 'hydraulic' model, which Deleuze and Guattari describe in terms of 'becoming and heterogeneity, as opposed to the stable, the eternal, the identical, the constant' (1980/1987, p. 361). Their use of 'hydraulic' here is meant to invoke fluid dynamics, or the study of the forms of fluidic behavior that emerge under different conditions. The point here is to emphasize that the minor-scientific approach attributes to the world a kind of novelty and self-organizing power that the major-scientific approach denies. According to the minor-scientific approach, regularities are not imposed by transcendent and eternal laws, rather they are immanent expressions of the world in its interactions with itself. And, importantly, such regularities are themselves susceptible to change. Just as water might exhibit one kind of regularity under certain conditions (laminar flow at low speed), so too might it exhibit other regularities or behaviors under other conditions (convection or turbulence at greater speeds). The 'minor' practitioner therefore experiments with dynamic systems (or refers to such experiments) in order to discover those thresholds at which such systems manifest different behaviors and forms. 'Here, it is not exactly a question of extracting constants from variables but of placing the variables themselves in a state of continuous variation' (1980/1987, p. 369).

Note that the distinction between major and minor science is *not*, as Pickering proposes, a distinction between 'two kinds of science' (2010, p. 155) such that one may designate physics, for example, as a major science and certain kinds of chemistry and biology as minor sciences. Rather, the distinction is one between different 'treatment [s] of science' (1980/1987, p. 361), 'different modes of formalization' (1980/1987, p. 362), or between one 'conception of science' (1980/1987, pp. 362, 368) and another:

What we have [...] are two formally different conceptions of science, and, ontologically, a single field of interaction in which royal science continually appropriates the contents of vague or nomad science while nomad science continually cuts the contents of royal science loose.

(1980/1987, p. 367)

Thus, for Deleuze and Guattari, the 'major' and 'minor' distinction presents two different approaches to the *representation* of scientific theories (to borrow some language from contemporary philosophy of science). They are interested in different ways in which *any and all of the sciences* can be represented as well as in how these different modes of representation portray the ontological commitments of the sciences differently. The 'major' approach is described as 'theorematic' (1980/1987, p. 362) or 'axiomatic' (1980/1987, p. 373), labels that betray a potential resemblance to the 'syntactic' approach to theories in the analytic tradition, according to which such theories are conceived as collections of sentences whose relations to one another are understood by means of first-order quantificational logic. The 'minor' approach, on the other hand, is described as 'problematic' (1980/1987, p. 362), as couched in terms of 'a qualitative calculus' (1980/1987, p. 364) or 'differential equations irreducible to the algebraic

form' (1980/1987, p. 369). These descriptions betray a potential resemblance to the 'semantic' approach to theories in contemporary philosophy of science, which also foregrounds the role of mathematics. I am unable to pursue this line of inquiry here<sup>48</sup>; the point is simply to highlight that Deleuze and Guattari's distinction between major and minor science does not represent a division between particular sciences but rather different approaches to understanding their formal and ontological commitments.

So, why does this distinction challenge the non-naturalistic interpretative strategy examined above? Well, because it allows for genuinely scientific contact (in the 'minor' sense) with the world's ultimately relational or differential nature. To rephrase Mader's claim to the contrary (2017, p. 275), this distinction *does* enjoin (minor) science to adopt the project of ontology that is philosophy's pursuit. And the fact that Deleuze and Guattari explicitly allow for this possibility cannot be accommodated if we take *What is Philosophy?* as the authoritative account of Deleuze's views on science.

This distinction allows us to propose a new resolution to the question of Deleuze's naturalism (or the problem of reconciling Deleuze's two levels of engagement with the sciences). Since Deleuze and Guattari adopt different notions of 'science', and since these notions of science correspond to our two levels, these levels no longer need to be reconciled and thus the underdetermination exhibited by Deleuze's statement of interest in 'the metaphysics science needs' no longer needs to be broken. Deleuze is critical and Bergsonian with respect to science in the 'major' sense (the science of the first level of engagement detailed in *What is Philosophy?*), and he is naturalistic with respect to science approached in the appropriate 'minor' way (the way exhibited by the second level of engagement). When it comes to the relation of the sciences to Deleuze's philosophical claims, then, we can claim that this relation is naturalistic in the relevant 'minor' sense.

## 7 | CONCLUSION

At this juncture, I can only sketch and propose, rather than expound or defend in any comprehensive way, this 'minor-naturalistic' interpretation of the relation between Deleuze's philosophical claims and his engagements with the sciences. My principal aim here is to revisit the very question of this relation, to contribute to an improved understanding of this question, and to do so by putting Deleuze's thought into more direct contact with contemporary philosophy of science. And I hope to have shown that engaging with the philosophy of science can indeed shed light on Deleuze's thought by, for example, showing that his project is in fact much more consistent with forms of ontological and methodological naturalism than it is often taken to be. I hope also to have collected and situated much of the relevant secondary literature, which can itself be as scattered and heterogenous as Deleuze's own writings, and to have provided at least some foothold in Deleuze's ideas for philosophers of science working out of the analytic tradition.

The intention here is not polemical—or at least not so with respect to any individual. Again, Deleuze's engagements with science and mathematics have not gone unacknowledged and there exists a wealth of valuable literature (including that cited in this essay) which exploits such engagements to illuminate his philosophical claims. But, in the few instances in which such literature turns to the precise nature of the relation between the sciences and Deleuze's philosophical thought, it can be hamstrung by its lack of engagement with some of our most sophisticated contemporary thinking about science. This expresses a fact about the ways in which we carve up and organize our discipline. Those with expertise in Deleuze are typically less likely to have expertise in contemporary philosophy of science—and vice versa. And yet, again as I hope to have shown, the latter sheds light on the former. Similarly, I suspect (as do some Deleuze scholars and philosophers of science) that Deleuze's conceptual lexicon might yield fruitful approaches to current debates in the philosophy of science, whether with respect to category-theoretical accounts of scientific representation (Dewar, 2023), the ontology of quantum gravity (Calamari, 2021), or some other domain of inquiry. Challenging the traditional boundaries of specialization therefore seems to be a valuable approach in our attempts to understand Deleuze, the sciences themselves, and the metaphysics science needs.



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## ENDNOTES

- <sup>1</sup> Others who emphasize these engagements (and who are not cited elsewhere in this essay) include Ansell Pearson (1999), Clisby (2017) and Duffy (2013). See also Marks (2006).
- <sup>2</sup> See also Protevi, who seeks to ‘show how Deleuze’s conceptual framework enables us to bring scientifically minded philosophers and philosophically minded scientists—as well as analytic and continental philosophers—into dialogue’ (2013, p. 14).
- <sup>3</sup> For a succinct account of the demise of materialism in light of developments in physics, see Brown and Ladyman (2009). For a similar account, one leveled directly against the ‘new materialism’ of DeLanda and others, see Zammito (2017).
- <sup>4</sup> See, for example, Deleuze’s ‘Lucretius and the Simulacrum’ essay, appended to his *Logic of Sense* (1969/1990).
- <sup>5</sup> See, for example, Ansell Pearson (1999, 2014, 2017), Ansell Pearson and Protevi (2016, pp. 38–43), Hayden (1997), Holmes (2012) and Johnson (2017).
- <sup>6</sup> Note that sheer engagement with the history of philosophy or aesthetics, for instance, need not disconfirm one’s naturalism. One might engage with these domains but make no attempt to derive metaphysical knowledge (or indeed any knowledge at all). One might also engage with these domains in a way that relates importantly to the scientific project. Many historical figures with whom Deleuze engages (e.g., Spinoza, Kant, Nietzsche, Bergson) themselves engaged with the sciences or in arguably naturalistic discourse. And recent work shows an emerging place for aesthetics in the context of scientific (and thus naturalistic) inquiry. See, for example, Ivanova (2021), Murphy (2022) and Murphy and Ivanova (2023).
- <sup>7</sup> Here I allude to Deleuze and Guattari’s endorsement of ‘rhizomatic’ structure (see Deleuze & Guattari, 1980/1987, pp. 3–25): ‘A rhizome has no beginning or end; it is always in the middle, between things, interbeing, *intermezzo*’ (1980/1987, p. 25).
- <sup>8</sup> Note that I differentiate myself from those who regard Deleuze’s works as more fragmentary. See, for example, Patton (2016, p. 350) for an alternative view.
- <sup>9</sup> ‘The primacy of identity, however conceived, defines the world of representation’ (1968/1994, p. xix).
- <sup>10</sup> Scientific and philosophical thinking about intensity goes back to medieval philosophy and has its origins in Aristotle. For more on the history of philosophical accounts of intensity and their influence on Deleuze, see Mader (2014).
- <sup>11</sup> Note that the precise nature of the relationship between the ‘virtual-actual’ and the ‘intensity’ terminology is a matter of some debate. See, for example, a recent special issue of *Deleuze and Guattari Studies*, edited by Bowden and Clisby (2011).
- <sup>12</sup> This list is by no means exhaustive. See also Price and Corry (2007) and Blanchard (2016).
- <sup>13</sup> Russell claims that *no science* refers to causes (1913, p. 1); Ross and Spurrett show this claim to be false (2007, pp. 14–20).
- <sup>14</sup> Even constructive empiricists such as van Fraassen recognize the centrality of modality to science. Though they ‘recognize no objective modality in nature’ (van Fraassen, 1980, p. 202), they do so not because they claim that commitment to objective modality is non-naturalistic but because such a commitment is inconsistent with their empiricism.
- <sup>15</sup> Lewis (1986) is the canonical representative of this view.
- <sup>16</sup> Wüthrich (2020) claims that Lewisian modal realism is non-naturalistic. Lewis conceptualizes his possible worlds as fundamentally spatiotemporal (1986, p. 71). And yet, the search for a theory of quantum gravity promises to eliminate spacetime from the fundamental architecture of the universe. Lewisian possible worlds are therefore not recognized by our best science and so are non-naturalistic in the ontological sense. Conversely, our actual world does not qualify as possible in Lewis’s terms: ‘his pluriverse, for all its ontological abundance, does not contain our world’ (Wüthrich, 2020, p. 233).

- <sup>17</sup> 'The task of modern philosophy has been defined: to overturn Platonism' (Deleuze, 1968/1994, p. 59); 'The poisoned gift of Platonism is to have introduced transcendence into philosophy, to have given transcendence a plausible philosophical meaning' (Deleuze, 1993/1997, p. 137); 'Every reaction against Platonism is a restoration of immanence in its full extension and in its purity, which forbids the return of any transcendence' (Deleuze, 1993/1997, p. 137).
- <sup>18</sup> The modal character of the virtual is evident even in Deleuze's later collaborative work with Guattari. See *A Thousand Plateaus*, in which the terms 'potential' and 'virtual' are once again identified with one another (1980/1987, p. 99). See also *What is Philosophy?*, in which Deleuze and Guattari describe the virtual as 'containing all possible particles and drawing out all possible forms' (1991/1994, p. 118) (an admittedly curious instance given Deleuze's critique of the concept of possibility).
- <sup>19</sup> Whether such 'examples' provide evidence or mere illustration remains an open question. (And indeed, the aim of this essay is to shed light on precisely this issue.)
- <sup>20</sup> 'Spooky' here does not share its sense with that non-naturalistic 'spookiness' currently under discussion.
- <sup>21</sup> This type of experimental situation was first hypothesized by Einstein, Podolsky, and Rosen (1935). In its original formulation it concerns the positions and momenta of particles; Bohm (1951) later modified the setup to concern spin. For a clear and concise account, see Maudlin (2019, pp. 25–29).
- <sup>22</sup> Forms of 'ontic structural realism' describe the world as nothing more than immanent objective modal structure, and do so based on consideration of quantum mechanics. See Ladyman et al. (2007) and French (2014).
- <sup>23</sup> Note that Ansell Pearson and Protevi's vocabulary here may not hew to the way in which naturalism or physicalism are described in the analytic tradition. For instance, no contemporary naturalist accepts the existence of a vital force or vital properties. See, for example, Brown and Ladyman (2009, p. 37) and Ladyman et al. (2007, p. 42). Also, though they distinguish nonreductive physicalism from (what we are calling) emergentism at the start of their essay, Ansell Pearson and Protevi appear to conflate the two when discussing Hans Jonas's account of a 'nonreductive physicalist and hence emergent status for organismic life' (2016, p. 37). Similarly, they appear to conflate reductive physicalism (roughly, the view that non-physical entities or properties are identical to physical entities or properties) with eliminativism (the view that there are no such non-physical entities or properties) when describing the 'eliminative posture' of the former and the consequent 'dispensability of the notion of vital, social, or mental properties' (2016, p. 34).
- <sup>24</sup> Hüttemann and Papineau argue that 'part-whole' and 'levels' physicalism can be held independently and thus 'should not be conflated' (2005, p. 33).
- <sup>25</sup> This has to do with the search for a theory of quantum gravity. 'It seems that in all the non-perturbative approaches to quantum gravity familiar macroscopic four-dimensional spacetime is dynamically emergent rather than fundamental' (Ladyman et al., 2007, p. 172). Less technically: 'None of the existing contenders for a theory of quantum gravity is consistent with the idea of the world as a spatio-temporal manifold with classical particles interacting locally' (Ladyman et al., 2007, p. 174).
- <sup>26</sup> Compare with DeLanda: 'The world may be mind-independent but it is not *scale-independent*' (DeLanda & Harman, 2017, p. 22).
- <sup>27</sup> The 'inter-level', 'intra-level' terminology is due to Hüttemann and Papineau (2005, p. 33).
- <sup>28</sup> Again, see DeLanda and Harman (2017, p. 22).
- <sup>29</sup> Ladyman et al. 'distance [themselves] from the positivists and align [their] attitude more closely with that of Pierce and pragmatism' (2007, p. 27). They cite Putnam approvingly: 'for the positivists, the whole idea was that the verification principle should *exclude* metaphysics [...] while for the pragmatists the idea was that it should *apply to* metaphysics, so that metaphysics might become a responsible and significant enterprise' (Putnam 1995, p. 293; cited in Ladyman et al., 2007, p. 27).
- <sup>30</sup> See McAllister (2017) for a succinct introduction to theoretical unification and surrounding issues.
- <sup>31</sup> One may claim that there is no unifying work to be done and thus no task for metaphysics in this sense. Cartwright (1999) and Dupré (1993) advocate such a view. But this position sits uncomfortably with the demonstrable tendency toward unification in the history of science just mentioned.
- <sup>32</sup> Many philosophers of science endorse a 'primacy of physics' constraint, according to which physics enjoys epistemic priority over the other sciences. Any attempt at naturalistic metaphysics should thus defer especially to physics. I do not include such a constraint in my account, partly because I think there are reasons for abandoning it, partly because I think emphasizing 'maximal conciliatoriness' is functionally identical to endorsing such a constraint, and partly because the question of whether a hierarchy of inter-theoretical commitments is compatible with Deleuze's philosophy remains open and is an issue unto itself, one which I do not have space to explore here.

- <sup>33</sup> This exchange took place in 1981 and was published in Villani's *La guêpe et l'orchidée* (1999, pp. 129–131). Here I cite the translation available in *Collapse*.
- <sup>34</sup> See, for example, Bonta and Protevi (2004, p. 12).
- <sup>35</sup> Deleuze makes an oblique reference to 'Child and Weiss' (1968/1994, p. 250), who are most likely Charles Manning Child and Paul Alfred Weiss. See, for instance, Child (1915) and Weiss (1939). (I am grateful to Charles Stivale—and, by extension, Gary Genosko and Daniel Smith—for their correspondence and help in determining these identities.) Deleuze's (and Deleuze and Guattari's) more overt references, though, are to Albert Dalcq's *L'œuf et son dynamisme organisateur* (1941). See Deleuze (1968/1994, p. 251) and Deleuze and Guattari (1980/1987, pp. 531–532). For more on the gradient-based embryology of this time, see Thieffry (2001).
- <sup>36</sup> Blastulation, gastrulation and neurulation—each of which is referenced by Deleuze (1968/1994, pp. 250–251)—are examples of such processes. See Wolpert (2011: Ch.4) for a helpful gloss.
- <sup>37</sup> See also Deleuze (1968/1994, p. 216).
- <sup>38</sup> Many of these seminars were recorded and are now the subject of an ongoing transcription and translation project. 'The Deleuze Seminars', co-directed by Daniel W. Smith and Charles J. Stivale, can be accessed online: <https://deleuze.cla.purdue.edu/>. When citing, I refer to the relevant date in parentheses. For example: (April 29, 1980).
- <sup>39</sup> Collected in Leibniz (1989).
- <sup>40</sup> For a reproduction of this diagram along with a brief treatment of Leibniz's essay, see Smith (2012, pp. 52–55). See also Deleuze (1988/1993, p. 18).
- <sup>41</sup> As he puts it in his book on Leibniz: 'the differential quotient [...] retains the relation [...] when these two magnitudes vanish' (1988/1993, p. 18).
- <sup>42</sup> Though Deleuze does not cite his sources, he refers to 'an essay by Poincaré on differential equations' as well as to 'the sequel to the essay' (April 29, 1980). This fact, in conjunction with the relevant subject matter, makes it likely that he is referring to parts one and two of Poincaré's 'Mémoire sur les courbes définies par une equation différentielle' (1881, 1882).
- <sup>43</sup> For Stivale's note on Marek's identity, see (January 27, 1987, n. 8).
- <sup>44</sup> For Marek's lecture, see (January 27, 1987). The solicitation: 'if I may dare, but you tell me sincerely if this bothers you or not, if you return another time, then I would obviously desire an intervention by you' (January 6, 1987).
- <sup>45</sup> At this point one might object, claiming accurate representation of scientific theories plus generalization from those theories into a broader ontological framework to be insufficient for naturalism in the relevant sense. One might find such theories philosophically interesting or productive as they are without necessarily taking them as evidence. Here the relation of science to philosophy would be something like 'inspiration'. That said, if inspiration is functionally identical to evidence (as it appears to be in this case), then our objector owes us some account of how to differentiate the two such that Deleuze comes out as non-naturalistic. Absent such an account, our naturalistic interpretation seems more plausible.
- <sup>46</sup> These include 'nodes' (*les nœuds*), 'saddles' (*les cols*), 'foci' (*les foyers*), and 'centres' (*les centres*) (Poincaré, 1881, p. 392). See Deleuze (April 29, 1980) for his discussion of these kinds of singular point.
- <sup>47</sup> For example, neither Ansell Pearson and Protevi (2016) nor Mader (2017) nor May (2005) nor Patton (2016) discuss this distinction.
- <sup>48</sup> Smith (2006) comes close to doing so.

## REFERENCES

- Ansell Pearson, K. (1999). *Germinal life: The difference and repetition of Deleuze*. Routledge.
- Ansell Pearson, K. (2014). Affirmative naturalism: Deleuze and epicureanism. *Cosmos and History: The Journal of Natural and Social Philosophy*, 10(2), 121–137.
- Ansell Pearson, K. (2017). Naturalism, norms, and ethics. In S. Ellenzweig & J. H. Zammito (Eds.), *The new politics of materialism*. Routledge.
- Ansell Pearson, K., & Protevi, J. (2016). Naturalism in the continental tradition. In K. J. Clark (Ed.), *The Blackwell companion to naturalism*. Wiley Blackwell.
- Armstrong, D. M. (1980). Naturalism, materialism and first philosophy. In D. M. Armstrong (Ed.), *The nature of mind and other essays*. University of Queensland Press.
- Bell, J. A. (2006). *Philosophy at the edge of chaos*. Toronto University Press.
- Bergson, H. (2007). Introduction to metaphysics. In H. Bergson (Ed.), *Creative mind: An introduction to metaphysics* (M. L. Anderson, Trans.). Dover (Original work published 1903).

- Bergson, H. (2023). *Creative evolution* (D. A. Landes, Trans.). Routledge (Original work published 1907).
- Bergson, H. (2004). *Time and free will: An essay on the immediate data of consciousness* (F. L. Pogson, Trans.). Routledge (Original work published 1889).
- Blanchard, T. (2016). Physics and causation. *Philosophy Compass*, 11, 256–266.
- Bohm, D. (1951). *Quantum theory*. Prentice-Hall.
- Bonta, M., & Protevi, J. (2004). *Deleuze and geophilosophy*. Edinburgh University Press.
- Bowden, S., & Clisby, D. (Eds.). (2011). The virtual, the actual and the intensive: Contentions, reflections and interpretations. *Deleuze and Guattari Studies*, 11(2), 153–155.
- Brown, R., & Ladyman, J. (2009). Physicalism, supervenience and the fundamental level. *The Philosophical Quarterly*, 59(234), 20–38.
- Bryant, L. (2020). Deleuze's infernal book: Reflections on *difference and repetition*. *Deleuze and Guattari Studies*, 14(1), 5–24.
- Calamari, M. (2021). The metaphysical challenge of loop quantum gravity. *Studies in History and Philosophy of Science Part A*, 86, 68–83.
- Cartwright, N. (1999). *The dappled world*. Cambridge University Press.
- Child, C. M. (1915). *Individuality in organisms*. University of Chicago Press.
- Clisby, D. (2017). Intensity in context: Thermodynamics and transcendental philosophy. *Deleuze Studies*, 11(2), 240–258.
- Dalcq, A. (1938). *Form and causality in early development*. Cambridge University Press.
- Dalcq, A. (1941). *L'oeuf et son dynamisme organisateur*. Albin Michel.
- de Beistegui, M. (2004). *Truth and genesis*. Indiana University Press.
- DeLanda, M. (2002). *Intensive science and virtual philosophy*. Continuum.
- DeLanda, M., & Harman, G. (2017). *The rise of realism*. Polity.
- Deleuze, G. (1990). In C. V. Boundas (Ed.), (M. Lester & C. Stivale, Trans.) *The logic of sense*. The Athlone Press (Original work published 1969).
- Deleuze, G. (1993). *The fold: Leibniz and the baroque* (T. Conley, Trans.). The Athlone Press (Original work published 1988).
- Deleuze, G. (1994). *Difference and repetition* (P. Patton, Trans.). The Athlone Press (Original work published 1968).
- Deleuze, G. (1997). *Essays critical and clinical*. (D. W. Smith & M. A. Greco, Trans.). University of Minnesota Press (Original work published 1993).
- Deleuze, G. (2010). Letter-preface by Gilles Deleuze. In J.-C. Martin (Ed.), *Variations: The philosophy of Gilles Deleuze* (C. V. Boundas & S. Dyrkton, Trans.). Edinburgh: Edinburgh University Press (Original work published 1993).
- Deleuze, G., & Guattari, F. (1983). *Anti-oedipus* (R. Hurley, M. Seem, & H. R. Lane, Trans.). University of Minnesota Press (Original work published 1972).
- Deleuze, G., & Guattari, F. (1987). *A thousand plateaus*. (B. Massumi, Trans.). University of Minnesota Press (Original work published 1980).
- Deleuze, G., & Guattari, F. (1994). *What is philosophy?* (H. Tomlinson & G. Burchell, Trans.). Columbia University Press (Original work published 1991).
- Deleuze, G., & Villani, A. (2007). Responses to questions. *Collapse*, 3, 39–43. (Original work published 1999).
- Dewar, N. (2023). On internal structure, categorical structure, and representation. *Philosophy of Science*, 90(1), 188–195.
- Duffy, S. (2004). Schizo-Math, *Angelaki*, 9(3), 199–215.
- Duffy, S. (2013). *Deleuze and the history of mathematics*. Bloomsbury.
- Dupré, J. (1993). *The disorder of things*. Harvard University Press.
- Einstein, A., Podolsky, R., & Rosen, N. (1935). Can quantum-mechanical description of physical reality be considered complete? *Physics Review*, 47, 777–780.
- Evens, A. (2000). Math anxiety. *Angelaki: Journal of Theoretical Humanities*, 5(3), 105–115.
- French, S. (2014). *The structure of the world*. Oxford University Press.
- Gaffney, P. (2010). *The force of the virtual: Deleuze, science, and philosophy*. University of Minnesota Press.
- Glymour, C. (1999). A mind is a terrible thing to waste—Critical notice: Jaegwon Kim, *mind in a physical world*. *Philosophy of Science*, 66, 455–471.
- Hayden, P. (1997). Gilles Deleuze and naturalism: A convergence with ecological theory and politics. *Environmental Ethics*, 19, 185–204.
- Holmes, B. (2012). Deleuze, Lucretius, and the simulacrum of naturalism. In B. Holmes & W. H. Shearin (Eds.), *Dynamic reading: Studies in the reception of epicureanism*. Oxford University Press.
- Hüttemann, A., & Papineau, D. (2005). Physicalism decomposed. *Analysis*, 65(1), 33–39.
- Ismael, J. (2017). An empiricist's guide to objective modality. In M. Slater & Z. Yudell (Eds.), *Metaphysics and the philosophy of science: New essays*. Oxford University Press.
- Ivanova, M. (2021). The aesthetics of scientific experiments. *Philosophy Compass*, 16(3), 1–9.
- Johnson, R. (2017). *The Deleuze-Lucretius encounter*. Edinburgh University Press.
- Ladyman, J. (2004). Constructive empiricism and modal metaphysics: A reply to Monton and van Fraassen. *The British Journal for the Philosophy of Science*, 55(4), 755–765.

- Ladyman, J. (2008). Structural realism and the relationship between the special sciences and physics. *Philosophy of Science*, 75(5), 744–755.
- Ladyman, J. (2017). An apology for naturalized metaphysics. In M. Slater & Z. Yudell (Eds.), *Metaphysics and the philosophy of science: New essays*. Oxford University Press.
- Ladyman, J., Ross, D., Spurrett, D., & Collier, J. (2007). *Every thing must go*. Oxford University Press.
- Leibniz, G. W. (1989). *Philosophical papers and letters*, (L. E. Loemker ed. and Trans.). Kluwer.
- Lewis, D. K. (1986). *On the plurality of worlds*. Blackwell.
- Mader, M. B. (2014). Whence intensity? Deleuze and the revival of a concept. In A. Beaulieu, E. Kazarian, & J. Sushytska (Eds.), *Gilles Deleuze and metaphysics*. Lexington.
- Mader, M. B. (2017). Philosophical and scientific intensity in the thought of Gilles Deleuze. *Deleuze Studies*, 11(2), 257–277.
- Marks, J. (Ed.). (2006). Deleuze and science. *Paragraph*, 29(2), 81–97.
- Massumi, B. (1992). *A user's guide to capitalism and schizophrenia: Deviations from Deleuze and Guattari*. MIT Press.
- Maudlin, T. (2019). *Philosophy of physics: Quantum theory*. Princeton University Press.
- May, T. (2005). Gilles Deleuze, difference, and science. In G. Gutting (Ed.), *Continental philosophy of science*. Blackwell.
- McAllister, J. W. (2017). Unification of theories. In W. H. Newton-Smith (Ed.), *A companion to the philosophy of science*. Blackwell.
- Murphy, A. (2022). Imagination in science. *Philosophy Compass*, 17(6), 1–12.
- Murphy, A., & Ivanova, M. (Eds.). (2023). *The aesthetics of scientific experiments*. Routledge.
- Norton, J. (2007). Causation as folk science. In H. Price & R. Corry (Eds.), *Causation, physics and the constitution of reality*. Oxford University Press.
- Papineau, D. (1993). *Philosophical naturalism*. Blackwell.
- Patton, P. (2016). Deleuze and Naturalism. *International Journal of Philosophical Studies*, 24(3), 348–364.
- Pickering, A. (2010). Cybernetics as nomad science. In C. B. Jensen & K. Rödje (Eds.), *Deleuzian intersections: Science, technology, anthropology*. Berghahn.
- Poincaré, H. (1881). Mémoire sur les courbes définies par une equation différentielle (1ère partie). *Journal de Mathématiques Pures et Appliquées*, 7, 375–422.
- Poincaré, H. (1882). Mémoire sur les courbes définies par une equation différentielle (2nde partie). *Journal de Mathématiques Pures et Appliquées*, 8, 251–296.
- Price, H., & Corry, R. (Eds.). (2007). *Causation, physics, and the constitution of reality: Russell's republic revisited*. Oxford University Press.
- Protevi, J. (2013). *Life, war, earth: Deleuze and the sciences*. University of Minnesota Press.
- Putnam, H. (1995). Pragmatism. *Proceedings of the Aristotelian Society*, 95, 291–306.
- Redhead, M. (1990). Explanation. *Royal Institute of Philosophy Supplement*, 27, 135–154.
- Russell, B. (1913). On the notion of cause. *Proceedings of the Aristotelian Society*, 13, 1–26.
- Schaffer, J. (2003). Is there a fundamental level? *Noûs*, 37(3), 498–517.
- Smith, D. W. (2006). Axiomatics and problematics as two modes of formalisation: Deleuze's epistemology of mathematics. In S. Duffy (Ed.), *Virtual mathematics: The logic of difference*. Manchester.
- Smith, D. W. (2012). *Essays on Deleuze*. Edinburgh University Press.
- Thieffry, D. (2001). Rationalizing early embryogenesis in the 1930s: Albert Dalcq on gradients and fields. *Journal of the History of Biology*, 34(1), 149–181.
- van Fraassen, B. C. (1980). *The scientific image*. Clarendon Press.
- van Fraassen, B. C., & Peschard, I. (2008). Identity over time: Objectively, subjectively. *The Philosophical Quarterly*, 58(230), 15–35.
- Villani, A. (1999). *La guêpe et l'orchidée: essai sur Gilles Deleuze*. Belin.
- Weiss, P. A. (1939). *Principles of development*. Hafner Publishing Company.
- Wolpert, L. (2011). *Developmental biology: A very short introduction*. Oxford University Press.
- Wüthrich, C. (2020). When the actual world is not even possible. In D. Glick, G. Darby, & A. Marmodoro (Eds.), *The foundation of reality: Fundamentality, space, and time*. Oxford University Press.
- Zammito, J. H. (2017). Concluding (irenic) postscript. In J. H. Zammito & S. Ellenzweig (Eds.), *The new politics of materialism: History, philosophy, science*. Routledge.

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